

### **3.3 ES&H PROTECTION SYSTEMS**

#### **3.3.1 Prompt Radiation Control**

##### **3.3.1.1 Shielding Design and Layout**

During facility design, construction, modifications, and additions since 1970 or earlier to the present, shielding standards and practices have evolved. This section will give a physical description of the shielding around the accelerator and beamlines as it exists now. Evaluation of the shielding will be given in Section 4.

###### **3.3.1.1.1 Linac**

From the start of the linac heading east through the switchyard, the beamlines are underground in a tunnel. A service aisle runs along above the linac thru the switchyard. The drift-tube linac (DTL) is in the Sector A tunnel, shielded on top by concrete and earthen backfill (largely compacted native tuff) and on the south by a poured concrete wall 6' thick at the low-energy end. The wall increases in thickness toward the high energy end; in the region of Tank 4 it is 12.5' thick and is composed of concrete and tuff. The tunnel ceiling is 12 feet underground with respect to the earth level on the north side. The minimum thickness of concrete and backfill overhead is 7', which occurs in the four rf line trenches; otherwise the DTL tunnel overburden is 12' thick (construction drawing LAM-C-A-15). The four Sector A vertical service shafts are filled with sand to a depth of 7'. The west end of Sector A (low energy end) is lightly shielded—below about the 5' level, by a 2'-thick block wall; above the 6'-high beamline, by blocks and by a thin metal plate sufficient to block personnel access from the injector side and x-rays from the DTL.

The side-coupled linac (SCL) is in the Sector B-H tunnel, which is underground with respect to the earth level on the north and south sides. The tunnel is shielded on top by concrete and earthen backfill (largely compacted native tuff) of 25.6' thickness (LAM-E-A-14). The outside ground level north and south is approximately level with the service aisle overhead of the tunnel. The linac tunnel is divided between Sectors B and C by a magnetite block shielding wall 6' thick. This permits 211 MeV-mode operation while sectors downstream of D are occupied. A personnel access safety system (PACS) fence/gate is at one end of Sector D to prevent close approach to the B/C shielding wall when the 211 MeV mode is ready. Sector B has a "Truck Access Door" at the tunnel floor level exiting to the Injector Building Parking Lot. It is made of concrete 6' thick and is one of the few

moveable shield doors in the facility. The doorway faces the linac at about the center of Module 5, where the beam energy is 108 MeV.

The filled space between the linac tunnel and the SCL service aisle overhead has 45 vertical service shafts of  $3.5' \times 6'$  cross section. These shafts are filled with sand to provide shielding equivalent to the surrounding backfill, except for the transition region (TR) shaft. This is partly filled with sand, has a block wall stacked around the top, and a shielding layer overhead to prevent high radiation on the building roof in the most extreme situations. The waveguides in Sectors B-H have bends that reduce neutron ducting.

Stairwells connect the service aisle to the linac tunnel in Sectors B-H and in some cases there are hoist or elevator shafts (Figure 3-14). A maze in the horizontal run from the bottom of the stairs to the linac tunnel attenuates the maximum radiation level possible at the PACS door entering the maze. In Sector G, the elevator shaft reduces the shielding thickness horizontally between the linac and the stairwell; to allow personnel access to the pump room on the middle level (Room 302G) but not to the bottom of the stairwell during beam operation, a personnel access gate has been installed in the stairwell below the middle level. At the end of the linac, the beam enters the Switchyard area (SY or Sector S).

#### **3.3.1.1.2 Switchyard (SY)**

The SY (Figure 3-10) is in a branching tunnel 11' high that is underground on the north side. The floor area in the SY is 1' higher than in the linac tunnel, so nominal beam height is 5'. Overhead is the SY service aisle on the same level as the linac service aisle. There is an overburden of backfill plus concrete floor and roof 25.5' thick up to the Area A stairway, which goes down 11.5' to the Area A balcony level (referred to as the "Merrimac" level on the original drawings). The SY tunnel is separated from the Line D North tunnel by a steel shielding wall (and personnel access door and maze).

The Line A branch of the switchyard tunnel is underground on the north side (this area also contains a valve gallery in an alcove on the north wall) and continues under the "Merrimac" mezzanine level of Area A. The tunnel shielding overhead consists of magnetite concrete and aggregate backfill 14' thick. On the south side of the tunnel, on the other side of a wall made of 1.5' thick concrete, 3.5' magnetite aggregate, 2.75' steel, and 3.25' concrete backfill, is a room partly occupied by the inactive "TOFI" system.

Two branches of the Line D North tunnel (see Figure 3-10) lead out southward to a paved area where the ground level is close to the floor level of the tunnel, largely as a result of natural site contours. One branch of this forked tunnel, used only for the heaviest equipment transport, has moveable shielding completely blocking the entrance. The other branch is the Line D North personnel access route and has a shielding maze. The earth level

slopes from the SY Service Aisle level 36.5' above the tunnel floor down to the pavement grade. Its minimum thickness viewed from the Line D beamline is ~ 7.1'.

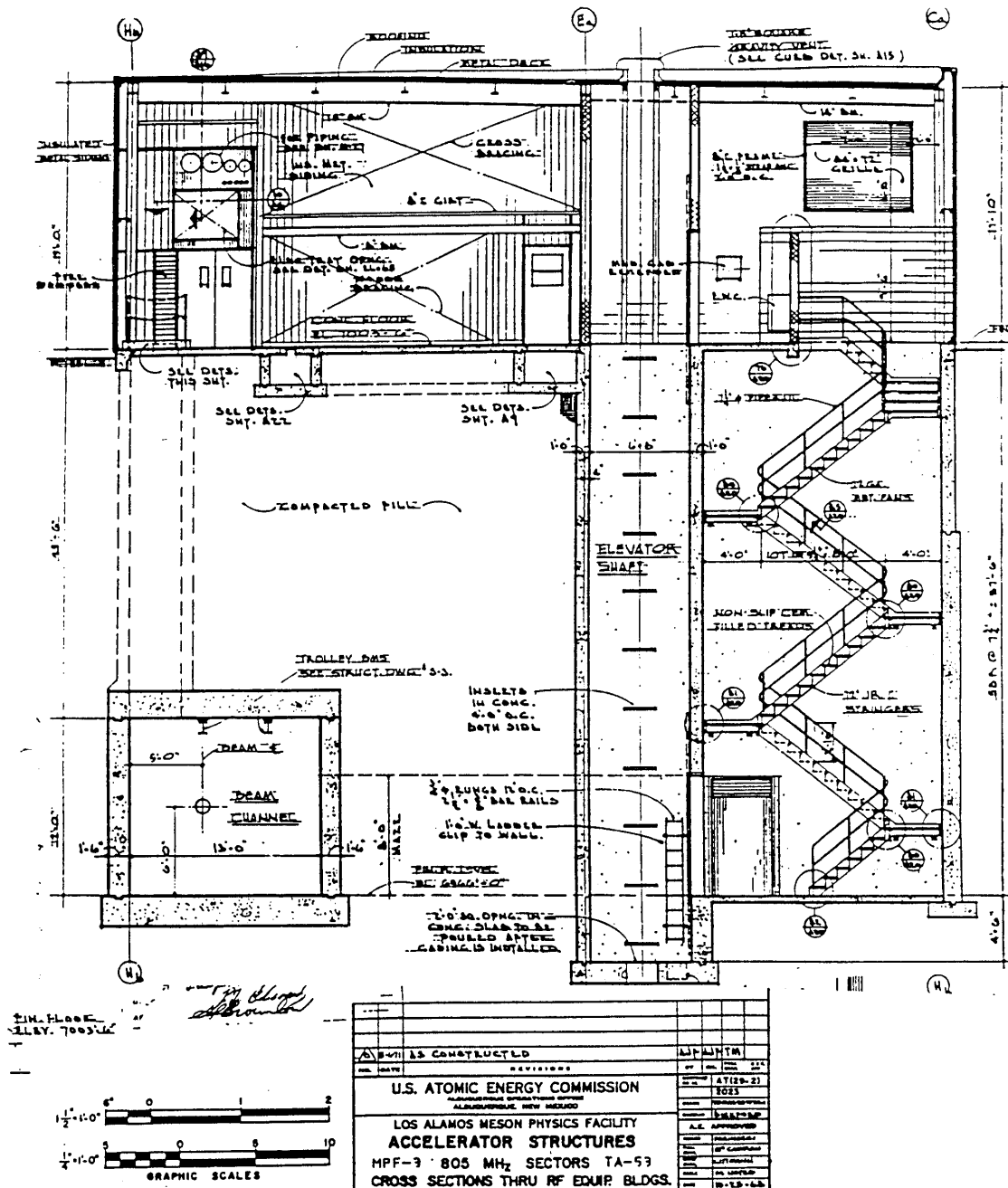


Figure 3-14. Linac stairwell and elevator shaft.

Another branch of the SY tunnel turns left 45° for Line X. This branch ends in a stacked magnetite concrete block wall. The beamlines split here, penetrate the wall, and continue as Lines B and C.

#### **3.3.1.1.3 Line D**

The Line D beamline turns right in the SY, ramps down 27', and passes south in a tunnel under the paved area referred to above with a minimum of 17' thickness of mixed material overburden. Shielding blocks and fences are used in the paved area to augment radiation protection. Where La Mesita road crosses over the beam tunnel, 5.5' of steel shielding is installed above the beam line, between the tunnel and the road.

Just south of La Mesita road, the geometry becomes more complicated. One branch of Line D goes down and to the right to the PSR, then comes back up to the same elevation in the same tunnel, then bends left and down to the 1L target. The other branch of Line D (1R) eventually bends right to the WNR. See Figures 3-15 and 3-16.

Because of the complicated geometry and ongoing upgrades, a 3-D model of all Line D areas is maintained in a computer-aided design (CAD) system as controlled documentation (Appendix 3-1).

#### **3.3.1.1.4 PSR**

For PSR, the minimum shielding thickness facing accessible areas during beam operation is 14.5' of concrete on the west side, shielding the access maze. Between the PSR and its equipment building directly overhead is a 23' thickness of concrete and earth shielding (Fitzgerald 1992).

Although these beamlines are below the grade of La Mesita road, some areas which can be occupied by personnel are below or to the side of them. The geometry and shielding have been thoroughly assessed (Fitzgerald 1990, 1991, 1993a, b).

#### **3.3.1.1.5 MLNSC**

Beam from the PSR eventually reaches the 1L beamline, which bends vertically downward into the neutron spallation target (Target 1 or 1L), located in the center of a heavily-shielded crypt (Figures 3-15 and 3-16). At the elevation of the nominal center of the 1L target and outside of the beam tubes, the minimum shielding thickness radially in the direction of areas occupiable when beam is on is 4.4 m of steel and magnetite concrete (79% and 21% by volume, respectively) in the inner core of the bulk shield and 0.3 m of boron-loaded magnetite concrete around the outside. Figure 3-17 shows the MLNSC experimental hall layout. ER-1 is the original room around the 1L target. ER-2 is a large newer experimental hall on the east side of ER-1.

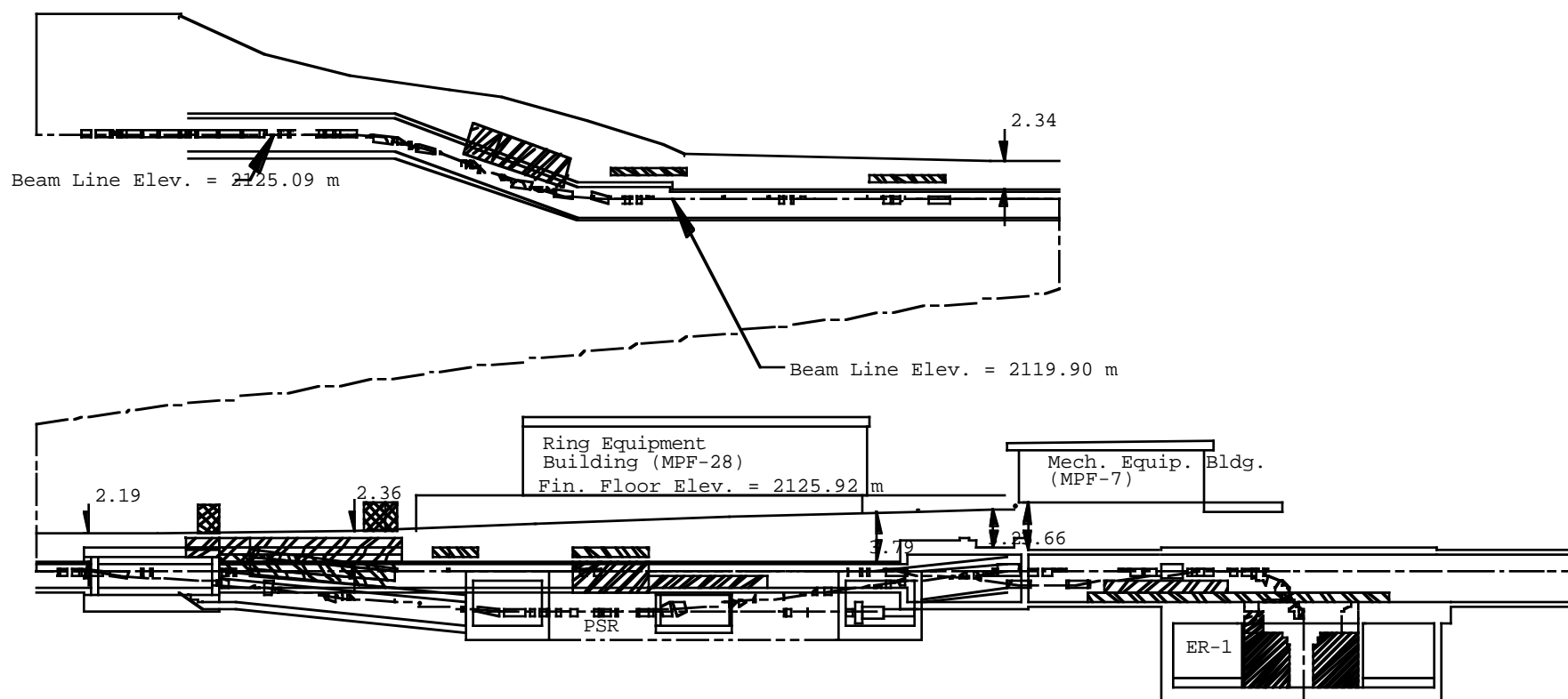


Figure 3-15. Line D profile and plan views.

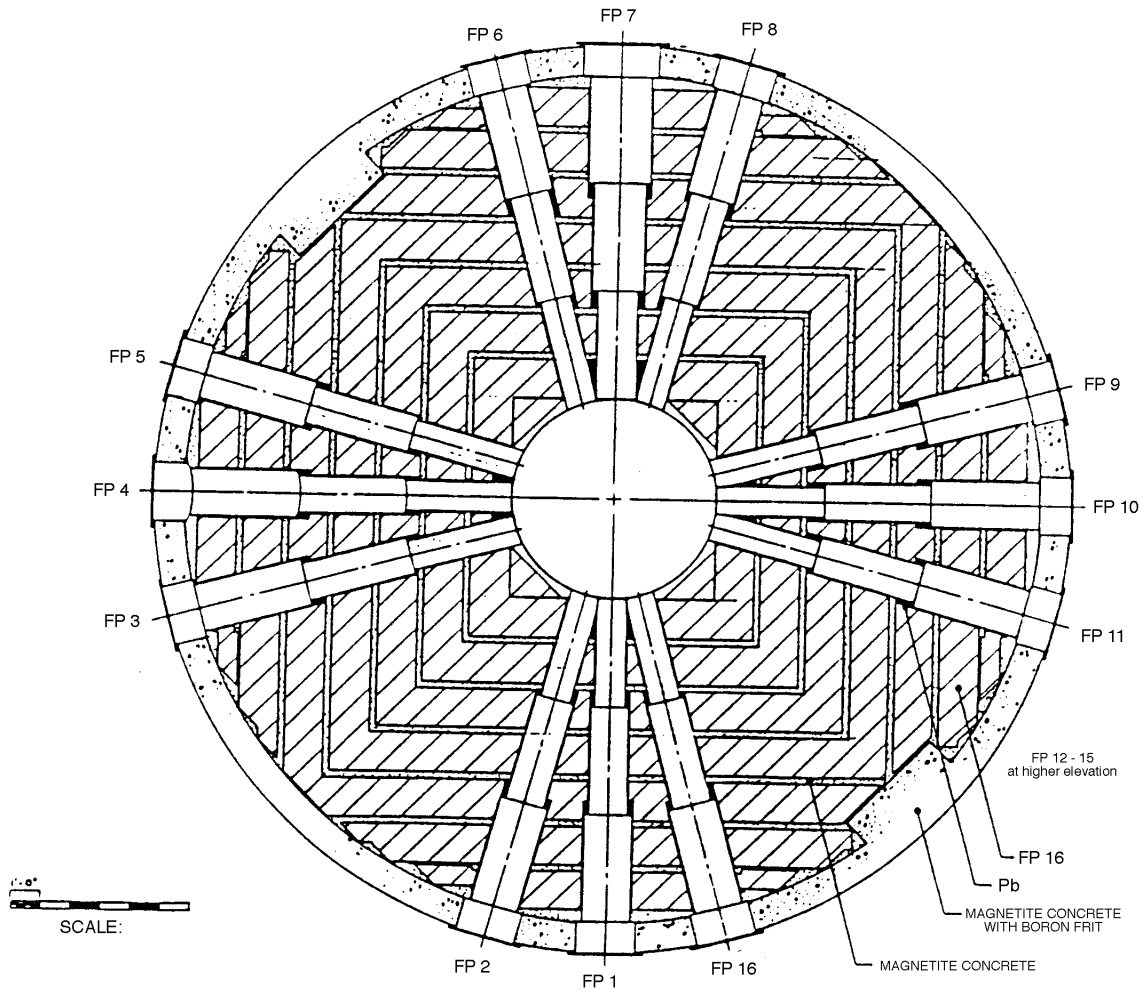


Figure 3-16. 1L target shielding.

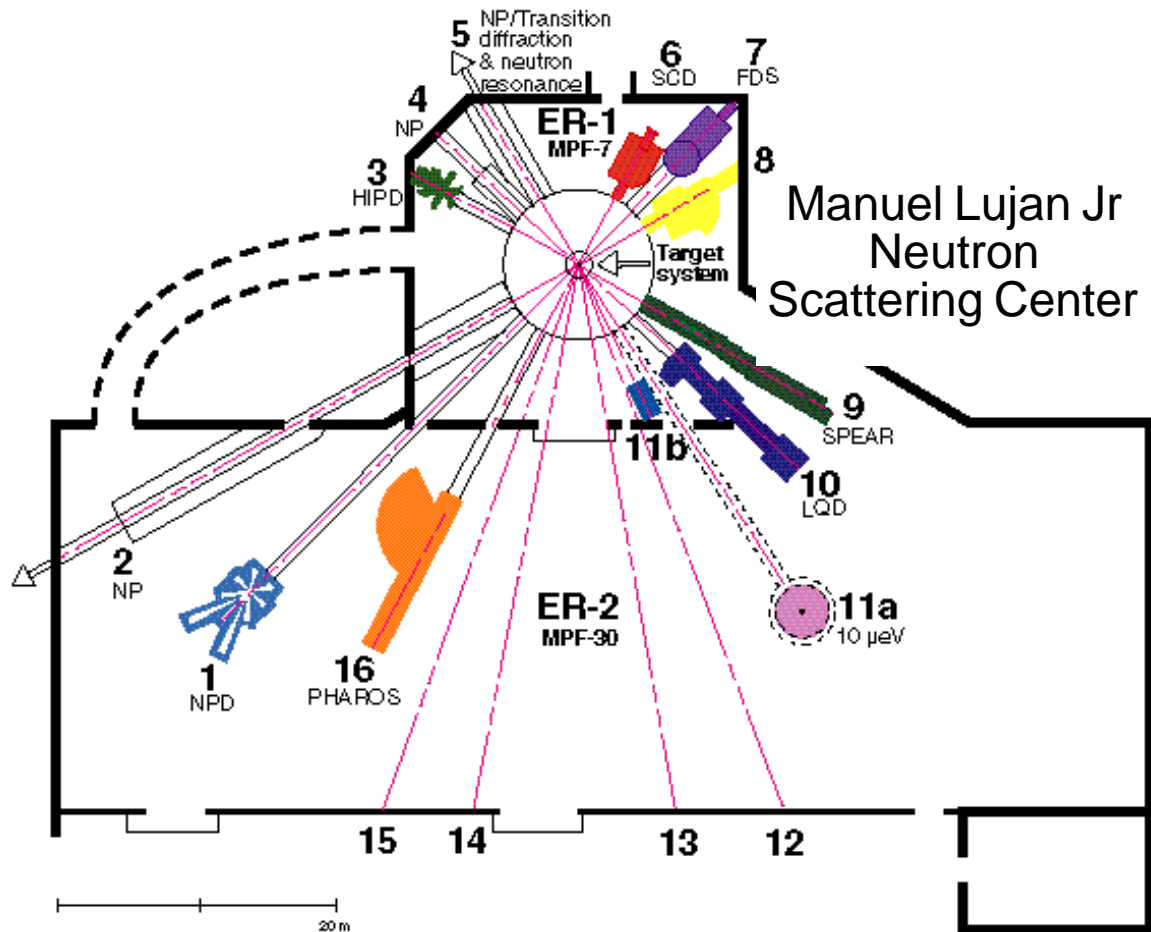


Figure 3-17. MLNSC Experimental Rooms 1 and 2 (ER-1 and ER-2).

### 3.3.1.1.6 WNR

The WNR beamline can be terminated in the Target 2 (“Blue Room”) or continued to Target 4 (the “White Source”). The Blue Room has a concrete dome 0.2 m thick and is covered with 4.9 m of earth, minimum. Target 4 is in a concrete block crypt of minimum ~6 m wall and roof thickness. This area is illustrated in Figures 3-18 and 3-19. The minimum shielding thickness between the 1R beamline and ER1 is 3.3 m of tuff and 0.6 m of ordinary concrete.

Building structures are integrated with the radiation shields that surround Targets 2 and 4. Target shields, shown in Figures 3-19 and 3-20, are designed to reduce radiation leakage into occupied areas to dose equivalent levels below 1 mrem/hr at design beam

currents. The Target 4 shield, MPF-369, also serves to confine the activated materials inside.

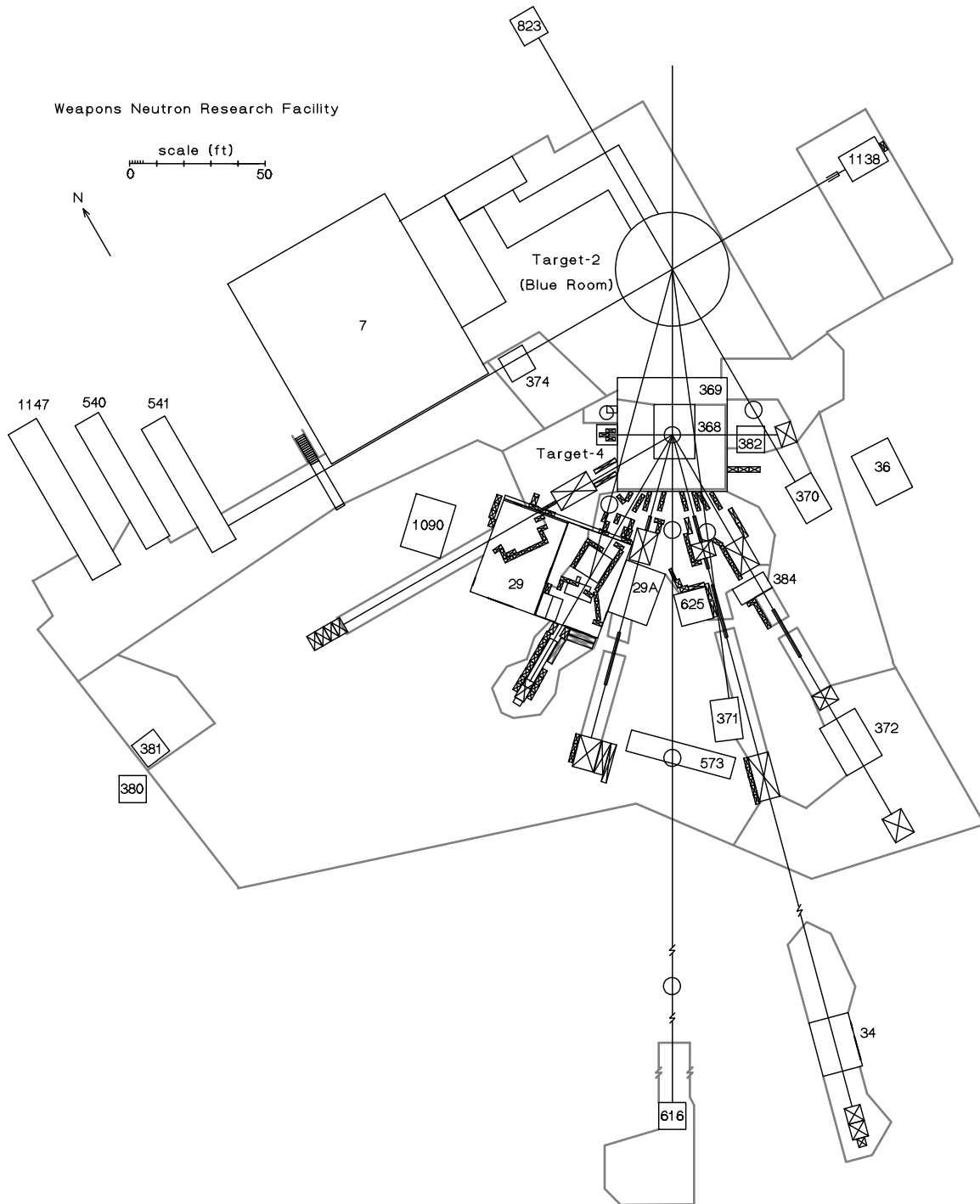


Figure 3-18. Layout of WNR experiment facilities.

The Target 2 shield is adequate for a target scattering or stopping 100 nA of beam. Experiments that require insertion of target or sample material into the beam in the Blue Room are designed, evaluated, and approved individually, and may require temporary



access control nearby. Neutron flight paths through the shield are plugged with iron, polyethylene, water, or sand when not in use.

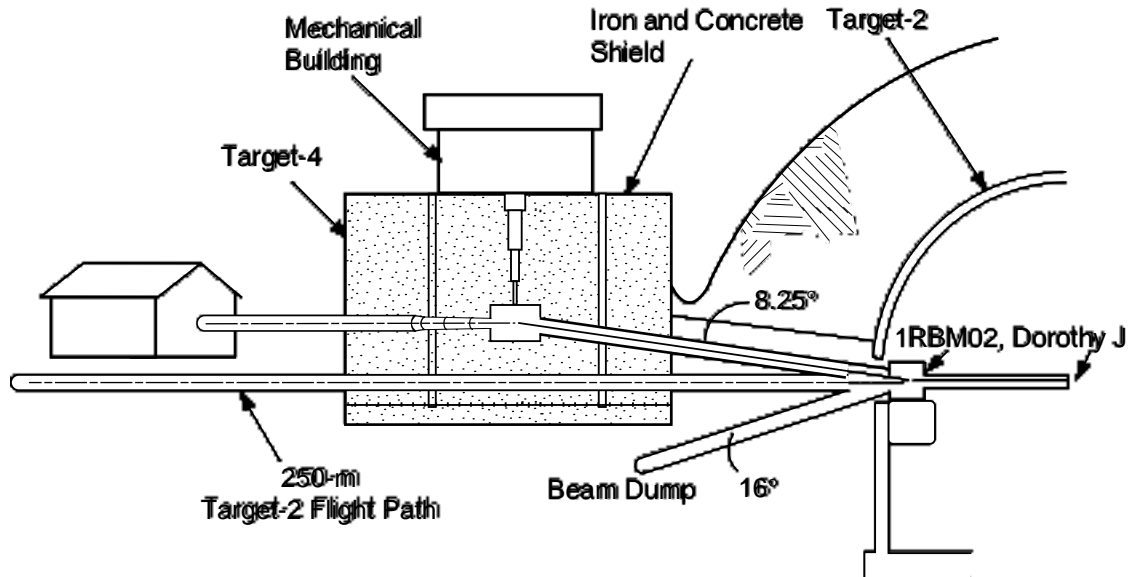


Figure 3-19. Elevation view of Target 4.

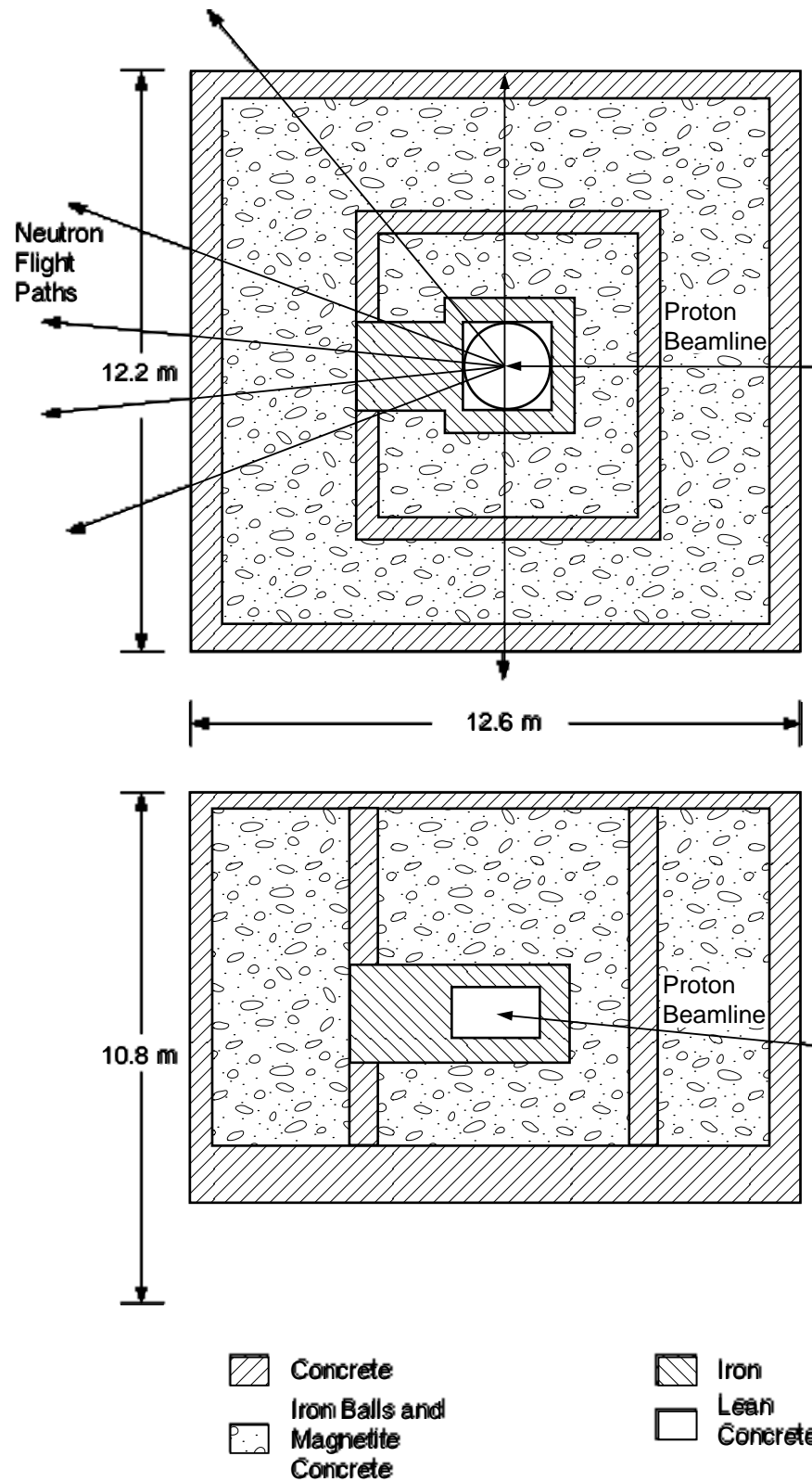


Figure 3-20. Horizontal and vertical sections of the Target 4 shield.

### **3.3.1.1.7 Area A**

Line A heads east from the switchyard under the stairs from the SY service aisle and goes under the “mezzanine” floor. The shielding under the floor is partly magnetite and is 14' thick. After exiting the mezzanine bulkhead, the beamline is 5' above the floor in Area A and is surrounded by heavy movable shielding. The beamline in Area A includes the A1 and A2 Target Cells, covered with 14' of steel, where a fraction of the beam interacts with targets to produce secondary beams transported in four beam channels as shown in Figure 3-10 to the Area A experimental caves. Elsewhere the minimum shielding thickness is 14' of concrete. The Area A experimental caves are enclosed on the sides by shielding blocks typically 10' high and 2–3' thick except for the access mazes and gates. The shielding thickness is largely incidental to the function of providing a self-supporting personnel access barrier.

The beamline continues through A-East to A6. The A-East beamline is largely within a permanent tunnel with no overhead access. The shielding is partly fixed construction and partly stacked blocks. The A6 Area includes additional targeting facilities. These include a target to enhance neutrino production and an insertable “stringer” system for material irradiations for Radiation Effects studies (REF) and Isotope Production (IP). The stringer shafts are potential openings for ducting radiation. Therefore the stringers are interlocked, the IP building is locked with a controlled key during beam operation, and “shadow blocks” are installed outside the building in line with the stringer ports.

### **3.3.1.1.8 Line X**

Line X bends 45° left (northeast) and splits into Lines B and C just upstream of the shielding wall that defines the northeast boundary of the switchyard, as shown in Figure 3-11. The minimum shielding thickness is overhead and consists of 14' thick concrete and earth backfill.

### **3.3.1.1.9 Lines B and C**

Downstream of the shielding wall, Lines B and C pass through the Line B tunnel. The tunnel is enclosed on the sides by concrete and backfill of minimum thickness 27.4'. The lower floor of Equipment Room B is overhead, shielded by concrete and backfill of minimum thickness 17'. Line B passes through the southeast side of Area B and enters the beam stop crypt. The beamline in Area B is enclosed in heavy steel shielding in the direction of occupiable areas, except for equipment penetrations and the door and maze entering the beam stop crypt. The beamline can also be terminated in the Line B tunnel.

Line C bends 120° left, delivers beam to an experimental target in Area C, and terminates in the LC beam stop, as shown in Figure 3-11. The room is covered by a 1.5' thick concrete dome and a minimum of 10' of earth, as shown in Figure 3-21. Except northwards, the room is underground. The entrance has a moveable concrete door 6' thick.

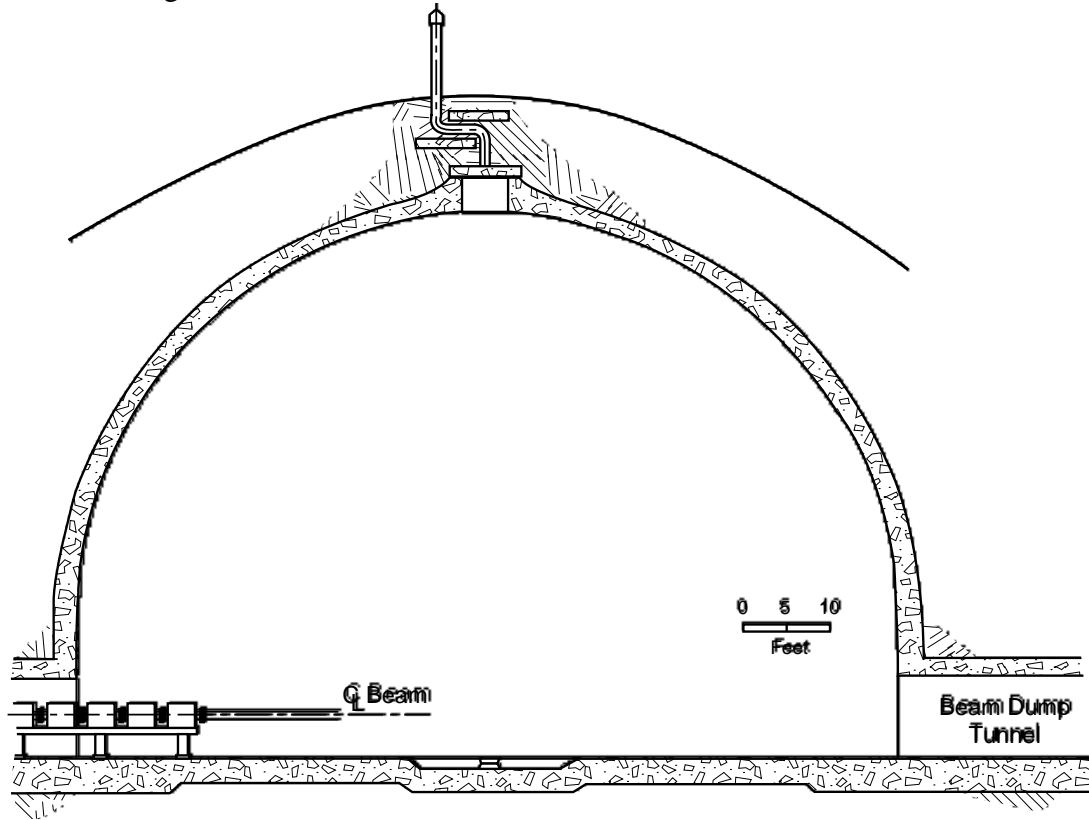


Figure 3-21. Elevation view of Area C.

#### 3.3.1.2 Radiation Security System (RSS)

The RSS provides risk reduction from the hazard of prompt radiation beyond the protection inherent in facility shielding and permanent barriers.

The RSS may be considered in three parts:

- Personnel Access Control System (PACS), described in a following section;
- Errant Beam Detection System;
- Beam Shutoff System.

The errant beam detection system acts through the RSS to help limit unwanted radiation. Elements in this system are described later and include beam current limiters, transmission monitors, beam loss monitors, and radiation monitors. The beam shutoff system terminates or prevents beam delivery if the PACS and errant beam detection system are not satisfied. The parts of the system are interconnected through the RSS “backbone.”

The RSS backbone includes wiring and logic used to provide positive (physical) beam shutoff in the accelerator if any downstream location is in neither Safe nor Ready mode. In other words, part of its function is facility-wide interconnection to ensure personnel safety throughout the facility before any beam can be run. PACS by itself is more local in action.

The RSS has two independent legs for redundancy and false-alarm indication. If one leg, say “B,” is Not Ready, then the RSS “B” leg beam plug cannot be retracted; if the leg faults during beam delivery, the “B” plug is automatically inserted. A beam plug is a piece of metal that is inserted into beam line to prevent passage of beam through that point. As shown in Figure 3-22, two sets of RSS beam plugs are in common beamlines shared by all beams ( $H^+$  and  $H^-$ ) (except in MLNSC). The fault will also turn off all beams instantly through non-RSS channels and cause several other beam plugs to be inserted. Each injector transport line has a Run Permit (RP) beam plug for tuning. There is one RP tuning plug in the common transport line; downstream are the two primary Radiation Safety System (RSS) venting plugs (see below), which are not normally hit by beam. The three-plug sequence is repeated at the 211 MeV point. In the beam switchyard,  $H^+$  can be sent to the Switchyard beamstop SYBS or Line A. If Area A is not ready for beam, the Line A RP plugs are required to be in to provide RSS beam ready in order to run beam to the switchyard. A similar pattern occurs in Line D and Line X. None of the 800 MeV plugs have the venting feature and they are not inserted directly by a downstream RSS fault; therefore, they are not considered full RSS-level plugs. Run modes end in beam plugs up to 211 MeV; past that, all run modes end in stopping targets rather than insertable beam plugs.

Each run mode endpoint is indicated in Figure 3-22 by a \*.

RSS feeds the other interlock systems such as beam permissive interlocks but not vice versa. Figure 3-23 shows the interlock hierarchy. The RSS connection to beam permissive interlocks means that in principle primary beam should never strike the RSS beam plugs.

The RSS beam plugs in the Low Energy Transport and at Module 14 have a venting feature to spoil the accelerator vacuum (which terminates the beam) if electronic inhibits fail or the tuneup beam plugs fail to insert and high-intensity beam reaches the RSS plugs (Cohen 1992). The venting feature is an air volume in the plug, which has two (for checking and redundancy) room air inlet tubes. This avoids a possible burn-through condition where beam could pass downstream.

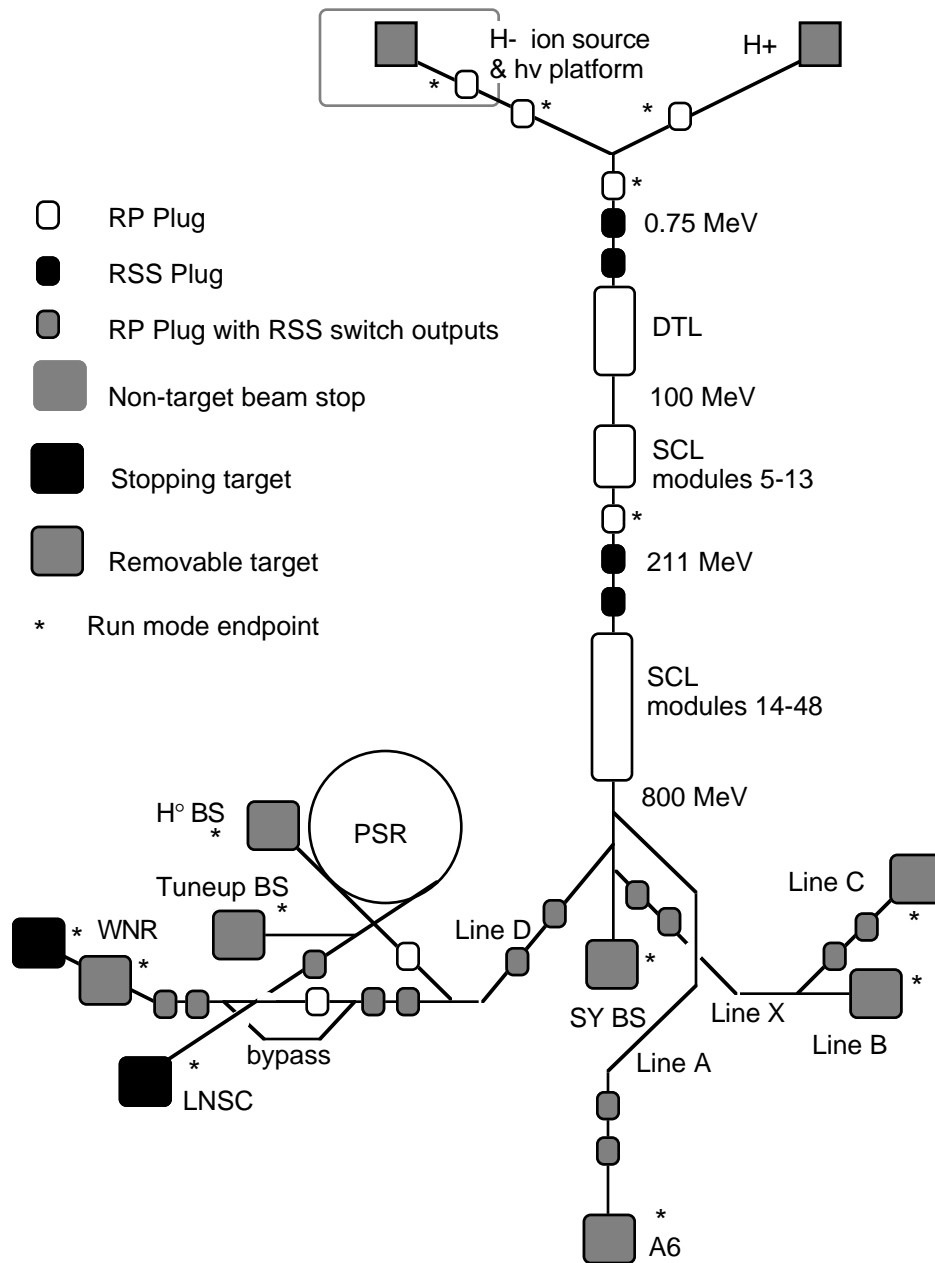


Figure 3-22. Run Mode and Beam Plug Diagram.

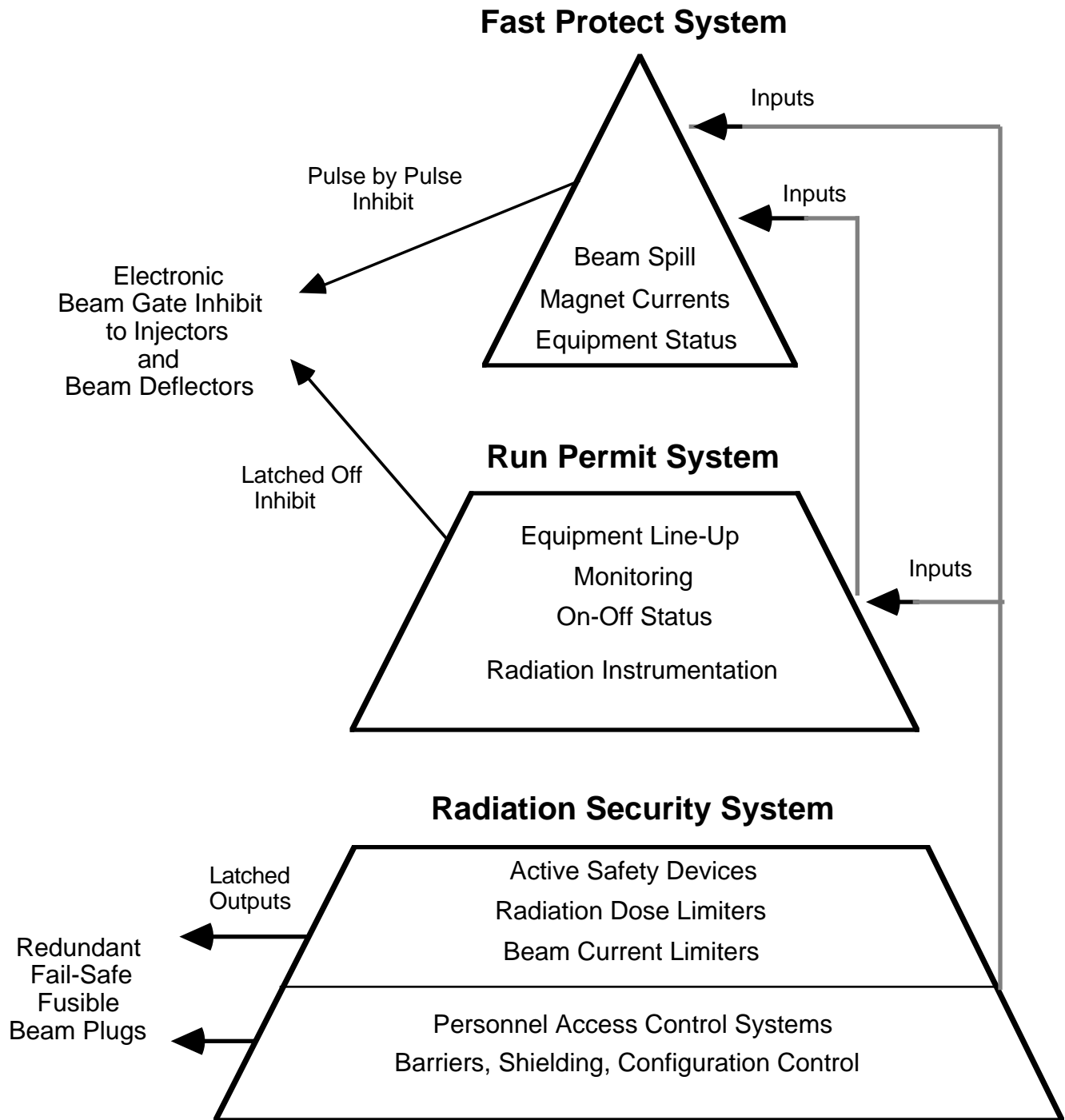


Figure 3-23. Hierarchy of accelerator beam interlock systems.

The basic RSS logic is shown in Figure 3-24. Standards for the system include LANL Standard LS-107-01 and the following design principles:

- high reliability
- components and materials of high grade for dependability and long life
- radiation-resistant materials where levels are high enough to cause damage
- false trips to minimum; minimize challenges to the system
- design as simple as possible, consistent with protection needed
- fail-safe components and circuits
- duplicate circuits or redundant components used in critical applications
- two methods to remove the beam
- exceptions to redundancy require risk analysis and management approval
- cables and connections protected (can have long runs in cable trays)
- locked junction boxes
- RSS boxes, racks, etc. labeled
- status reporting to identify faults
- control computer used for monitoring only
- no other systems input to RSS

RSS implementation is the responsibility of the Accelerator Operations Group. Oversight of the RSS in detail is provided by the LANSCE Operational Safety Committee; for example, configuration changes are reviewed by this committee. In some cases, implementation of local PACS installations and other RSS inputs may be done by separate facility operating organizations (e.g., MLNSC and WNR). Design principles are also reviewed by the TA-53 Radiation Safety Committee.

#### **3.3.1.2.1 Logic and Wiring**

RSS wiring diagrams are kept in a controlled documentation system; a formal control system is being developed. The document control procedure is specified in a LANL memorandum (Harris 1991). Copies of the diagrams are available from the Accelerator Operating Group, AOT-6.

#### **3.3.1.2.2 Personnel Access Control System**

The PACS is the exclusion area interlock subsystem to RSS. For normal operation, it is the only essential part of the beam delivery safety system. In earlier documentation this subsystem is referred to as the Personnel Safety System (PSS).

The beam delivery complex is divided into many separate beam delivery areas, and each beam area has personnel access control barriers and mechanisms interlocked with



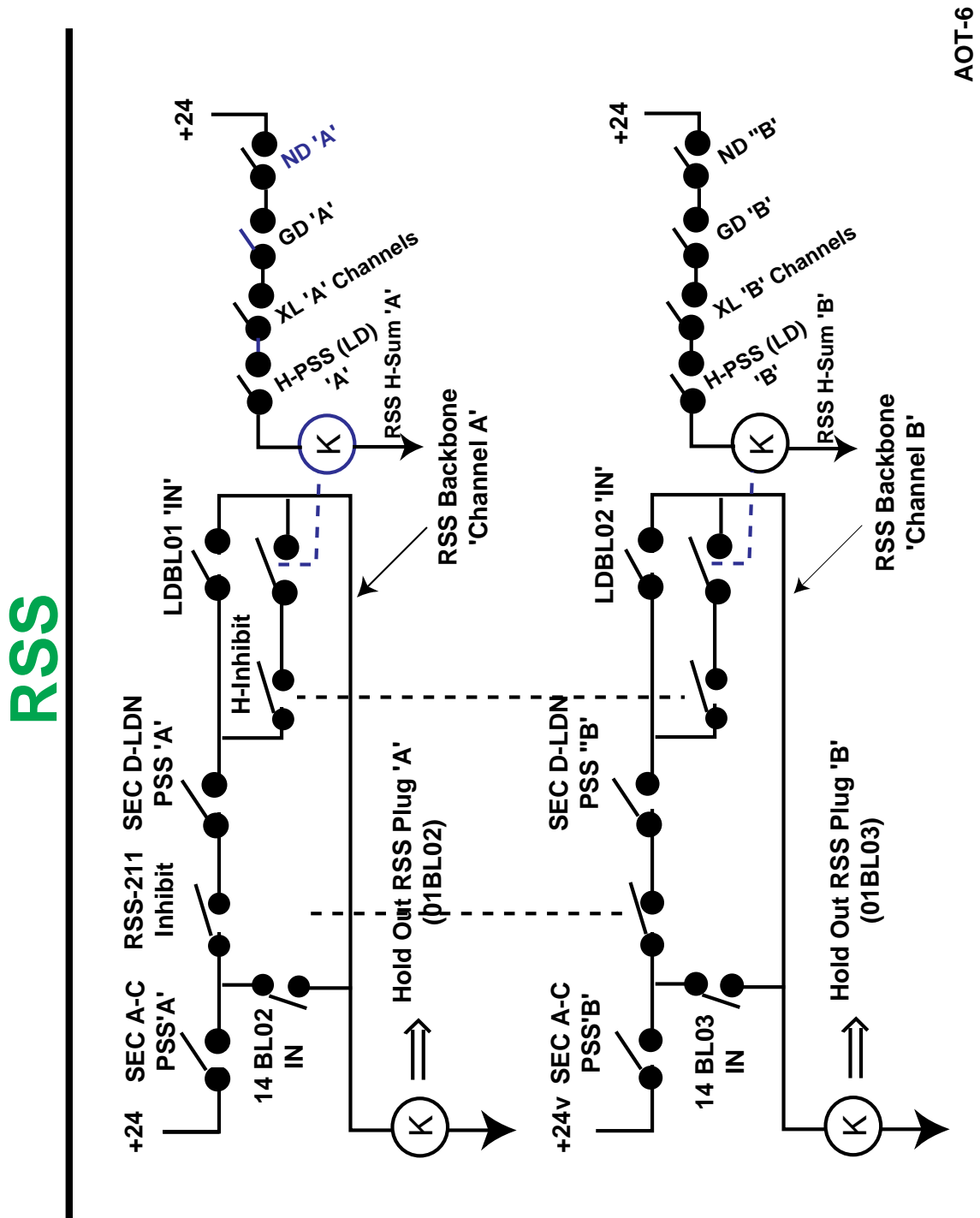


Figure 3-24. Radiation Security System (RSS) logic diagram.

beam plugs. This interlock system plus proper action with regard to personnel sweeps keeps excludes beam from out of occupied areas, and vice versa.

A beam area PACS status can be *open, ready for beam, in sweep, or faulted*; some areas have other possibilities such as *Controlled Access*. The PACS logic compares the status of the beam plugs into its area and the sweep state to supply an OK input to RSS (absence of the OK input is Not OK).

PACS is used for both primary beam and secondary beam area access. The primary beam RSS plugs, 01BL2–3 and 14BL2–3, are the PACS plugs for the primary beam tunnels, e.g., to retract and hold out either pair, the next downstream area PACS has to indicate Ready for Beam.

Although at least two beam plugs are typically used to prevent beam delivery, in some cases an essential beam control element such as a bending magnet power supply replaces one plug, when it is possible to assure an equivalent level of protection.

PACS enclosures can also be used for areas which have no direct beam delivery but are considered to be possible High Radiation Areas from prompt radiation during normal operation. Similarly, the PACS is used incidentally to maintain access control to areas hot from residual activation, and to areas where equipment might be generating high radiation. In addition to beam-interlocked PACS enclosures, some high-radiation low-usage areas without direct beam delivery can have barrier-and-lockup systems without interlocks. The PACS is also used to control access to the injector high-voltage enclosures (the Faraday Cages).

#### **3.3.1.2.2.1 Barriers**

During normal operation, beam delivery areas are presumed to be High or Very High Radiation Areas according to the usual definitions (10 CFR 835, LANL RadCon Manual, etc.) and have a posted PACS perimeter that is defined unambiguously by personnel barriers. All primary beamlines are inside complete (three-dimensional) enclosures. Some secondary beamlines and incidental high radiation areas are not enclosed on top. These have at least a 6' wall or fence above any adjacent climbing surface.

#### **3.3.1.2.2.2 Gates and Keys**

Access to PACS-controlled areas is normally provided by interlocked gates. Each beam delivery area gate has interlocks and a Kirk Key key release system. The Kirk Key system has one transfer key and multiple releasable keys. Each releasable key can unlock the gate. Each person entering under the Controlled Access condition is required to take a key.

Return of all keys provides a positive check ensuring no one is left behind when the area is locked up again, in addition to the check provided by the search (sweep) procedure.

Each Kirk Key bank has a spare key or keys kept in the Accelerator Operations Group PACS Key Locker, available for emergency use or to replace broken keys. If a key cannot be accounted for, the key bank is recored. The current procedure for control of the spare keys is documented (Jones 1994).

At present (1996) all key releases require either that the PACS status is Safe (beam plug in) or, for all primary beam tunnel gates, key release command from the CCR. A PACS logic upgrade is in progress so that all key releases will require the Safe condition.

All gates are being upgraded to have two closure indicator switches.

#### ***3.3.1.2.2.3 Sweep and Access Control Procedure***

PACS Sweep and Entry procedures are kept in the AOT-6 Operations Manual. Appendix 3-2 gives one sweep and entry procedure as an example.

The procedures for primary and secondary beamlines differ in personnel qualifications permitted to enter and sweep. Primary beam areas usually require Health Physics surveys for entry. Secondary beam areas can be entered and swept by one person, including any trained experimenter.

The sweep procedure uses reset buttons placed to enforce thorough inspection of the area. Sweeps start and end with warning horns. Scram buttons are available in the area to abort the beam delivery if a person is left inside.

The IPSS, Instrument Personnel Safety Systems, are the PSS equivalent in MLNSC. These systems prevent beam delivery to MLNSC if any of the neutron scattering instruments is either not ready for beam or does not have its shutter closed. An instrument is made secure (for access) or ready for beam by sweeping the instrument caves (if any) and locking the access to the cave or sample chamber. An instrument is made safe by fully closing the target shield neutron shutter for that flight path. Interlocks for each flight path prevent access to caves and sample chambers with the shutter open, and prevent opening the shutter unless the caves have been swept and the instrument made ready for beam.

#### **3.3.1.2.3 Beam Plugs, Shutters, and other Blocking Devices**

Beam plugs, shutters, and other physical blocking methods are used to provide personnel safety in downstream areas, regardless of electronic beam inhibits which might also be used. There is a great variety of these devices, depending upon the intended function and the nature of the beam. For safety system purposes, blocking devices are used

in pairs, except in the MLNSC neutron beamlines. For other purposes, such as beam tuning, one plug is used.

Primary beam plugs are remotely insertable. Safety system (RSS/PACS) plugs are capable of taking full available beam power or have the venting feature described above in 3.3.1.2 to force accelerator shutdown if beam power is too high. Tuning plugs typically are limited in power handling capability but are thick enough to completely stop the beam. [Figure 3-22 showed accelerator PACS and Run Permit (beam delivery mode) beam plugs from the injector transport lines through the switchyard.] All Run Permit plugs are capable of stopping the full-energy beam for at least a few minutes, but none of the plugs in the switchyard are used for tuneup and the PACS will prevent high-power beam delivery to these plugs; low-power beam for tuneup is diverted to fixed beam stops in the switchyard for this purpose. Only the final beam stops and targets have sufficient power handling capability to receive beam at full power.

Most secondary beamlines have two beam plugs. The MLNSC neutron beamlines use multiply interlocked single liquid mercury cells, termed beam shutters, to block the beam.

Other blockers in use include de-energized beam bending magnets, applicable when located so that beam cannot be transmitted when they are off. This method is allowed to replace one of two beam plugs, provided the physical features (e.g., lockable energy source) are in place to enable an equivalent level of configuration control.

Each primary beamline has a final beam stop; these are not actuatable. Because of their much lower power, secondary beams usually have no beam stop distinct from the cave walls.

#### **3.3.1.2.4 Current Limiters**

Beam current transformer-detector systems are used to measure beam current; this is a standard accelerator technology. A specialized version (the “XL” device) is used at LANSCE to issue RSS faults when beam current is excessive. Since the basic measurement principle employed is the current transformer, they are intrinsically reliable. The RSS version has a high level of fail-safe engineering and sophisticated continuous self-checking. It has been given a formal reliability analysis (Sharirli 1990).

The primary role for the beam current limiters is to ensure that intended beam current limits are not exceeded, for reasons of operational integrity. There are no direct personnel safety consequences from beam that exceeds these limits in the absence of compounding factors, as discussed in Chapter 4. Provisions for determining locations and thresholds for the current limiters are specified in the Operations Manual Section 6.11.

### **3.3.1.2.5 Gamma Detectors**

Fail-safe-engineered gamma radiation detectors (GDs) are used in the RSS (Plum 1989). The advantage of using gamma (very energetic x-ray) detectors is simplicity.

Simplicity and reliability are gained partly by using atmospheric-pressure nitrogen gas fill in the ion chamber; if the gas leaks and is replaced by air, the sensitivity decreases by less than 20%. The detector electronics is self-checking and has fail-safe features.

GDs are used in the Line D beam tunnels as beam loss monitors and are interlocked to prevent high beam current losses from being sustained. They are used with a similar device (IRs, or Ionization Chambers) that is connected to the Fast Protect system. The radiation level necessary to cause a trip in the IRs is lower than that in the RSS GDs to avoid challenging the RSS. The Accelerator Operations Group is responsible for positioning these devices and their locations are documented in the AOT-6 Operations Manual.

### **3.3.1.3 Physical Configuration Control**

Beam lockoff devices are used to isolate areas for maintenance operations, and a system of inspections and checklists is used to certify readiness of areas for beam delivery.

#### **3.3.1.3.1 Movable Shielding**

Use of movable shielding requires configuration control. Maintenance operations involving unstacking shielding or unblocking penetrations are likely to occur several times a year. A configuration control system administered by the Accelerator Operations Group is used to prevent beam delivery until the reassembly is certified. This system consists of a locking mechanism on the beam plugs or other lockable barrier and a checkoff procedure authorizing unlocking. When the support group is ready to release the area to the Operations Group for beam delivery, that portion of the checklist is signed. When the Accelerator Operations Group checklists are complete and it is ready to deliver beam, its lock is removed. Appendix 3-3 shows a checklist from the OpMan.

#### **3.3.1.3.2 Fences and Barriers**

Fences and barriers are inspected during area readiness reviews. Fences and barriers that are vulnerable to being moved during beam operation are locked or interlocked.

#### **3.3.1.3.3 RSS**

RSS wiring is largely in conduit or otherwise protected from tampering. Junctions are in locked panels or cabinets. Documentation was described above.

### 3.3.2 Radioactive Material Control

Control of radioactive material is a required function of the LANL Radiation Protection Program (RPP) and AR 3-4 for source control. At TA-53, administrative and physical controls are used in a graded approach for maintaining control of radioactive materials.

#### 3.3.2.1.1.1 *Physical Controls*

Personnel access controls are used to prevent inadvertent or unauthorized entry into an area that is classified as High Radiation because of material activation, and to prevent entry into Very High Radiation Areas.

Radioactive materials can be located either inside or outside of beam delivery exclusion areas. If inside, the beam delivery Personnel Access Control System is employed for access to hot areas due to presence of radioactive materials. During extended maintenance periods, the PACS keys are held by the RCTs and they supervise access to High Radiation Areas. During maintenance periods where shielding material is removed to gain access to highly activated components, temporary fences are erected to control access and gates to High Radiation Areas are kept locked by a special lock sequence or kept under observation by RCTs. Care is taken to ensure that ladders and other means for bypassing the barriers are removed from the area or are secured with a lock and key. More or less permanent High Radiation storage areas have permanent barriers with locks controlled by the RCTs.

Table 3-7. summarizes how access to areas with high radiation due to beam operation vs. material activation is controlled; “high activation” means presence of material that creates a High Radiation Area.

Special Nuclear Material (SNM) is controlled by both tight physical and administrative controls. FSS-12 oversees the program at the Laboratory and requires each group owning SNM to appoint a qualified custodian to oversee this material. This custodian is responsible

**Table 3-7. Access controls for High Radiation Areas.**

according to prompt radiation and high activation of material.

Beam area	Beam on	High activation	No high activation
Yes	Yes	Interlocked & posted	Interlocked & posted
Yes	No	Locked & posted Access controlled by RCTs	No controls
No	No	Posted and barriers in place, access controlled by RCTs	No controls

for keeping the material locked in an approved safe and for documenting the movement of the SNM and its condition. FSS-12 makes frequent audits of the documentation and physical location of the source. All other non-SNM sources are controlled under LANL Administrative Requirement 3-4 (AR 3-4).

### **3.3.2.1.1.2 *Administrative and Physical Controls***

All TA-53 radiological areas are posted in accordance with the LANL RadCon manual. The requirements for entry into these areas is at a minimum Radiological Worker I training and a TLD badge. For entry to more tightly controlled areas, Radiological Worker II training, a Radiological Work Permit (RWP), or a Standard Operating Procedure (SOP) may be required. The entry requirements are posted at the entries to all radiologically controlled areas at TA-53. The radiological posting is performed by ESH-1 in accordance with "Radiological Posting" (LS 107-02).

RWPs are handled under Laboratory Standard LS 107-02 and are initiated by the requesting organization to perform work in a radiologically controlled area. ESH-1, the workers, and the line organization must each fill out their own sections and the line management along with ESH-1 sign the RWP prior to any work commencing. RWPs are used for the duration of the job they are written for, not to exceed one calendar year.

SOPs are used in long-term routine operations that have risk associated with them. They are prepared by the line organization and reviewed by all affected ESH Division groups. Each SOP is only good for one year before it must be reviewed.

To assure that control of all radioactive material is maintained, ESH-1 performs routine surveys of all radiologically controlled areas following prescribed radiation monitoring instructions (RMI) (TA-53 RMI-26). The RMI prescribes the areas, type of survey, and frequency of all the routine monitoring performed at TA-53. In addition, all equipment and items leaving a controlled area are monitored for contamination and activation in accordance with Laboratory Policy LP107-04 "Documenting Equipment and Item Removal" (LP 107-04). This includes all the non-radioactive waste removed from the controlled areas. To verify that no radioactive material is removed from a controlled area ESH-1 performs a site survey of the entire complex at TA-53 once per calendar quarter as indicated in the RMI and performed in accordance with "Procedure for Conducting the Quarterly Site Radioactive Material (RAM) Survey" (TA-53 DP-212). The last line of defense protecting the loss of radioactive material is the Site Egress Monitor. This monitor is described in section 3.3.2.4 of this SAD. All violations of the laboratory Radiation Protection Plan (RPP) are reported to the facility manager at TA-53, the line management of the offending party, and ESH-12. ESH-12 performs the tracking and follow-up, noting trends and aiding in the minimization of such problems.

### **3.3.2.2 Contaminated Area Entry**

Contamination areas are set up in accordance with "Establishing, Operating, and Terminating Contamination Areas" (TA-53 DP-601). The RCTs and line organizations

establish these areas and post them with the current radiological conditions in accordance with “Radiological Posting” (LS 107-02) and as a Radioactive Materials Management Area (RMMA). If a high radiation area (greater than 100 mR/hr at 30 cm) is also present inside the contamination area, High Radiation Area work controls as directed by the LANL RadCon manual Chapter 3 are required to be instituted and the radiation levels posted at the entrance. The external survey is done in accordance with “External Radiation Survey Standard” (ESH-1-06-01) and “Surveying for External Radiation” (ESH-1-06-02). This area must have plastic covering the floor and walls of the work area as determined by ESH-1 and the operating groups. The contamination area is required to have only one entry/exit point, at which a “bootie line” is established. At this line, the entry requirements for personal protective equipment (PPE) must be posted. The posting is required to include donning (on the clean side) and doffing (on the contaminated side) requirements.

Control of the contamination is maintained by utilizing a large area swipe in accordance with “Procedures for Taking and Processing Smears/Large Area Swipes” (TA-53 DP-401) and “Performing Large-Area-Swipe Surveys” (ESH-1-02-05 ). A smear survey of all in-use contamination areas, adjacent buffer areas, and all walkways to portal monitors is required daily in accordance with “Surveying for Alpha and/or Beta/Gamma Contamination” (ESH-1-02-02). Inside the contamination area, air sampling is performed in accordance with “Air Monitoring Procedure” (TA-53 DP-214). If any radiation levels are greater than 5 mR/hr at 30 cm from any radiation source or if the background radiation levels are greater than 5 mR/hr, then supplementary dosimeters are required to be issued in accordance with “Issuing Pocket Dosimeters and Recording Exposure” (TA-53 DP-501). If contamination levels greater than those specified by the Laboratory RadCon Manual Table 2.2 are found in any area that is not posted as a Contaminated Area, the area is decontaminated or posted accordingly. The decontamination team consists of line operation personnel and support services contractor personnel with RCT oversight.

### **3.3.2.3 Personnel Contamination Monitoring**

All personnel working and/or observing activities inside a contamination area are Radiological Worker II trained and certified. All personnel and equipment entering the area are checked for contamination when leaving the Contamination Area. (Internal and external dosimetry are described in Section 3.3.3.) Personnel are allowed to proceed to a portal monitor for self-monitoring provided the following conditions are met:

- Only beta/gamma emitters are anticipated, based on the smear results
- An RCT is near enough to respond to the portal monitor.



If the above conditions are not met, frisking will be done by an RCT using handheld instruments in accordance with “Responding to External Personnel Contamination” (ESH-1-09-05). If contamination is found, decontamination operations will be performed in accordance with “Decontamination of Personnel” (TA-53 DP-602) in a low background area. The portal monitors used at TA-53 are either the Eberline Models PCM-1B or the PM-6A. Both monitors are gas proportional detector arrays used in detecting contamination on personnel. Monitoring systems are relocated according to need. In 1995, systems in use at TA-53 were located in the following locations:

- (1) MPF-1 D-wing,
- (2) MPF-3M (Merrimac balcony),
- (3) MPF-3M (Area-A East),
- (4) MPF-30 (ER-2),
- (5) MPF-8 (PSR),
- (6) MPF-3M (Area-A main entry), and
- (7) MPF-7 (1L Service Area).

The PCM-1B and the PM-6A are equipped with alarms that signal when radiation above the preset limits is detected. The detector(s) head which alarmed is indicated and

alarm lights and horns are activated. Both models are equipped with a “Trouble Alarm” which is activated under the following conditions:

- Counting gas low pressure
- Low count rate failure on any detector
- High count rate on any detector
- High background alarm on any detector
- Contaminated detector(s)

ESH-4 performs the maintenance and calibration and maintains official records for the personnel monitors. The calibration frequency is once per year. Daily operational checks are performed by ESH-1 following “Procedure for Routine Response Check of Portal Monitors” (TA-53 DP-306) and “Radiation Monitoring Instructions” (TA-53 RM-26).

All personnel clearing portal monitors are required to record and sign in the portal log book. If a contamination alarm is triggered and contamination is verified by an RCT, a Radiological Incident Report (RIR) is initiated in accordance with “Notification and Reporting of Radiological Incidents” (LP 107-01), “Procedure for Reporting Radiological Incidents at TA-53” (TA-53 DP-811), and the facility manager is notified for 5000.3B reporting determination. During beam operations many of the portal monitors may not function properly due to elevated background levels. When monitors are not operational, an “Out of Service” sign must be posted on the instruments and personnel are directed to the other nearby functioning portal monitors. When a portal is not functioning and no path has been established to a functioning portal, personnel who are leaving an area that is controlled for contamination must wear clean anti-contamination clothing to prevent the spread of contamination to clean areas. If the nearest functioning portal monitor is not in the same building, ESH-1 must be contacted for instructions and/or assistance.

If respirators were issued for use in a contamination area under the guidance of “Procedure for Respiratory Protection at TA-53” (TA-53 DP-506) and “Air Monitoring Procedure” (TA-53 DP-214), then nasal smears of all wearers must be taken in accordance with “Procedure for Conducting the TA-53 Bioassay Program at TA-53” (TA-53-DP-405).

#### **3.3.2.4 Radiological Area Equipment Removal**

All equipment being removed from a radiologically controlled area is monitored in accordance with ESH-1-07-01, “Requirements for Releasing Equipment and Items,” and

documented according to Laboratory Policy LP107-04, "Documenting Equipment and Item Removal." These areas include but are not limited to the following areas:

- Airborne Radioactivity Areas
- High Contamination Areas
- Contamination Areas
- Radiological Buffer Areas (contamination and activation control)
- Controlled Areas (controlled for contamination and activation)

Prior to removing the items from these areas the following must be considered:

- the item's destination
- potential for contamination or activation of internal and external surfaces
- contamination type, and
- factors that could skew survey results.

If the materials are destined for unconditional release to the public, the release criterion NDA (no detectable activity) is applied. If an item is being released to a controlled area or an uncontrolled area of the Laboratory, the release criteria used are those on Table 2-2 of the LANL RadCon Manual (RadCon) and Figure IV-1 of DOE Order 5400.5, respectively. Releases to uncontrolled areas of the laboratory of equipment and items that have contamination levels less than those specified in DOE Order 5400.5 but greater than NDA are required to be considered "conditional."

Items being removed from a radiological area to a controlled area can be surveyed using large-area swipes and portable instrument surveys. Items being removed from controlled areas to uncontrolled areas are surveyed by both portable instrumentation and a smear survey. Smears of areas larger than 100 cm<sup>2</sup> are encouraged; however the release criteria of 100 cm<sup>2</sup> are applied.

Items may be released to Controlled Areas if fixed and removable contamination levels for the radionuclide contaminate are less than those specified in Table 2-2 in the LANL RadCon Manual. If the radionuclide contaminate is unknown, the assumption is made that the most stringent case (in Table 2-2) for the type of radiation being emitted.

If removable contamination levels exceed those specified in Table 2-2, the item is not released to a controlled area without first being decontaminated (of all radioactive contamination) or packaged to contain the removable contamination. If fixed contamination remains on an item, it is labeled in accordance with "Radiological Posting" (LS 107-02) and/or "Documenting Equipment and Item Removal" (LP107-04) before it is removed to the Controlled Area.

### **3.3.2.5 Site Egress Radiation Monitor**

A NaI radiation detector has been placed under the exit lane at the TA-53 gate. The detector system is activated by a photoelectric switch that detects the presence of a vehicle passing over the manhole holding the detector. Detector electronics, located in the site entrance station a few feet away, are set to alarm at twice the background level as measured by an identical detector in the entrance station. When the alarm level is exceeded a red light and audible alarm are activated, alerting the vehicle driver to pull over and wait for ESH-1 personnel to arrive. Simultaneously, the alarm is transmitted to the CCR and the ESH-1 Section and Field Offices. A video tape recorder is also activated to record the registration plate of the vehicle as it pulls away from the detector location. (The video camera is always on and the video monitor is visible to the gate attendants in the site entrance station.)

### **3.3.2.6 Environmental Monitoring**

ESH Division administers the LANL Environmental Surveillance Program with the principle focus of routine monitoring for radioactive and non-radioactive pollutants on LANL sites and in the surrounding region. These activities document compliance with appropriate standards, identify trends, provide information for the public, document the environmental impact of LANL operations, and contribute to the general environmental knowledge. Detailed supplemental studies also are carried out to determine the extent of potential problems, to provide a basis for remedial action, and to gather further information on the surrounding environment. Samples are taken and data are collected to assess the following:

- external penetrating radiation;
- quantities of airborne emissions and liquid effluents;
- concentrations of chemicals and radionuclides in ambient air, surface waters and groundwater, municipal water supply, soils and sediments, and food stuffs; and
- environmental compliance.

These data are compared with standards, regulations, background levels, and continually collected meteorological data to assess the dose to the public, LANL employees, and the environment. These data are used to demonstrate LANL's compliance with the DOE and EPA exposure limits, National Emissions Standards for Hazardous Air Pollutants (NESHAP), the Federal Clean Air Act and the New Mexico Air Quality Control Act, the Clean Water Act and the Safe Drinking Water Act, the Resource Conservation and Recovery Act, and the National Environmental Policy Act of 1969. These activities are

governed by a series of policy, program, and procedural documents referenced in detail in the LANL Annual Environmental Surveillance Report and Radioactive Air Emissions Summary (LA-12674-ENV 1992, LA-12859-PR 1994).

### **3.3.2.7 Air monitoring**

Radioactive air contamination can be broken down into four classes: gases, tritium, tritiated water vapors, and particulates. The sources include intense radiation passing through air including water vapor, and vaporization of activated water. Airborne activated particulates are very low and expected to result from special activities (see below).

Air activation is monitored for environmental and ALARA considerations. Most of the activated air (about 90%) is collected via air exhaust ducts and is filtered and monitored before being discharged out of the exhaust stacks. Environmental monitoring is described later in Section 3.3.2.6.2, Stack Discharge Air Activation Detectors (FE-2 and FE-3). The next section describes the air monitoring equipment used for occupational protection.

#### **3.3.2.7.1 Room Air Activation Detectors**

Whenever operations involving potentially hazardous alpha-emitting samples are undertaken, continuous air monitors are maintained near the sample. These monitors are capable of making audible and visible alarms in the area and in the Central Control Room (CCR). Portable area survey instruments are also maintained in experiment areas for use by health physics personnel or employees to check for hot spots or potential contamination. The workplace air monitoring program is administered by ESH-1, implementing the requirements of "Air Monitoring Standard" (ESH-1-05-01). Workplace air monitoring is performed using air monitoring and sampling devices in occupied areas that have the potential for airborne radioactivity. The three primary methods for evaluating airborne radioactivity at TA-53 make use of Continuous Air Monitors (CAMs), portable air monitors (Giraffes), and flow-through air ionization chambers.

ESH-4 administers the LANL Radiation Instrumentation Program, which provides radiation instrumentation and measurement services to ensure that high-quality radiation monitoring equipment is used, maintained and calibrated throughout the Laboratory. Their program strives to meet the requirements of 10 CFR 835, ANSI N323m, and the LANL RadCon Manual.

All calibrations performed by ESH-4 are traceable to methodologies recommended by the National Institute of Standards and Technology (NIST). Instrument users are also required to performance test those instruments capable of being tested, either daily or before each use to ensure proper instrument response. Procedures used to calibrate and

maintain the instruments fall under a quality assurance program that follows the requirements of ANSI NQA.1 and 10 CFR 830.120. Calibration of these instruments is currently performed by ESH-4 at the frequencies prescribed for each instrument. ESH-1 and ESH-4 work together to ensure that monitoring equipment is sufficient for a given application. As necessary, samples representative of the radiological hazards are analyzed to determine the appropriate instrumentation.

#### **3.3.2.7.1.1 *Continuous Air Monitors (CAMs)***

The Eberline AMS-3 and AMS-4 beta CAM models and the Eberline Alpha 5a and Alpha 2 alpha CAM models are currently used at TA-53. These CAMs provide a real-time audible alarm to the local area and the CCR, which calls for an immediate evacuation. The CAMs are located near sources of potential airborne radioactivity where accidental conditions could cause an intake in excess of 50 cpm above background. Before monitoring is performed in the experimental areas during beam operation, AOT-6 is contacted to connect the CAM so that the alarm will sound in CCR. Both systems are also equipped with a failure alarm to indicate that an instrument is not counting pulses.

#### **3.3.2.7.1.2 *Portable Air Monitors–Giraffe Air Samplers***

The giraffe air samplers are the most commonly used air samplers at TA-53. They are used in areas where no airborne alpha radiation is present, where background beta/gamma levels may be too high for the beta CAMs, or when airborne concentrations are suspected to be elevated.

The giraffe operates by pulling air through a fiberglass filter and/or an activated charcoal filter. The fiberglass filter is a high efficiency filter and is 100% efficient to particulates with sizes > 0.5 microns. The activated charcoal filter is used in addition to the fiberglass filters for collecting radioactive vapors, which pass through fiberglass filters undetected. Filters are changed daily. Field measurements are performed, then the samples are sent to ESH-4 Health Physics Analysis Laboratory (HPAL) for gross alpha and beta counting and high resolution gamma spectroscopy. The results of the HPAL analysis, along with the chain of custody, are reviewed and filed for easy retrievability.

An ESH-1 site-specific procedure contains the specific operation instructions for the giraffe (TA-53 DP-214).

#### **3.3.2.7.1.3 *Flow-Through Ion Chambers***

A Kanne chamber is a flow-through ion chamber connected to a chart recorder, a vacuum pump, and either a LASL Model 39 integrating electrometer or a Keithley Model

412 Ammeter. Kanne chambers are used as area monitors for personnel protection, tritium stack monitoring, and diffuse emissions reporting. The Kanne chambers are mounted on portable carts and are located in areas where chronic releases of radioactive air can be found. The systems may be alarmed at the discretion of the ESH-1 Staff for notification of elevated levels in the surrounding areas. The standard monitoring locations and the use of the Kanne chambers at these specific locations (Figure 3-25) are described below.

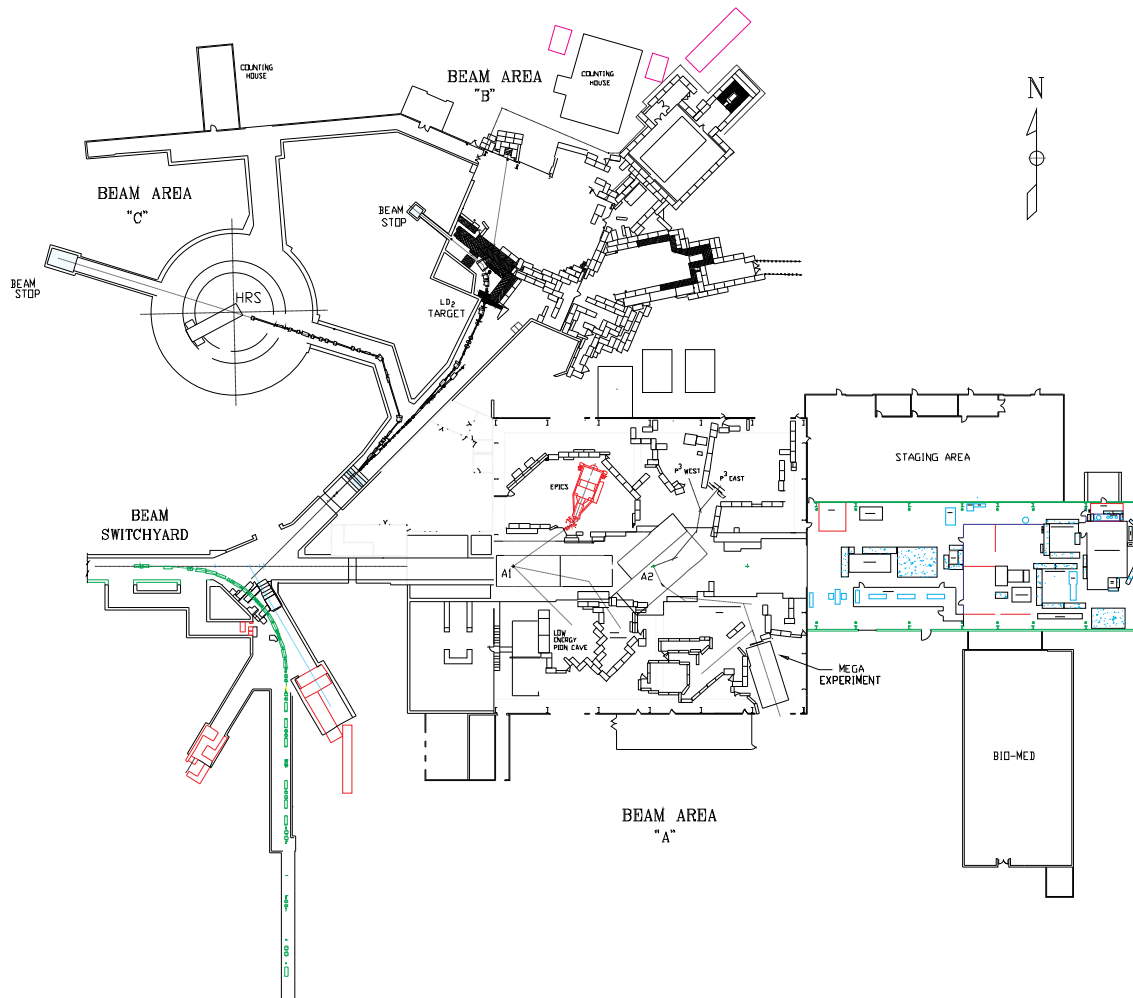


Figure 3-25. 1995 Air activation monitor locations.

#### *3.3.2.7.1.3.1 Switchyard*

The Kanne system monitoring the air in switchyard is used to determine entry requirements and for diffuse emissions reporting. It is located in the service aisle above the switchyard. Air is pulled up through a cable penetration, measured, and returned to the switchyard. This system is used to determine if the radioactive air concentrations are low enough to permit personnel to enter the switchyard for maintenance activities. It is only used when the accelerator is operating. If the Kanne system is not functioning, then a two hour non-entry period was enforced before any entry is made to the switchyard; presently this requirement is being evaluated, since SY air activation is minimal. The system also has a computer attached which logs the data in real time. The accumulated results are used to determine the diffuse emissions from the switchyard.

#### *3.3.2.7.1.3.2 Isotope Production*

At the Isotope Production facility the Kanne system with its attached computer is used primarily for diffuse emissions reporting. This is similar to the switchyard Kanne system. It is also used for determining entry requirements for the IP building. Typical radiation levels during operations may exceed 1 Rad (equivalent to 10,000 DACs) of radioactive gas inside the building. Because of the high radiation levels inside the IP building, a delayed entry procedure is used after beam is turned off.

#### *3.3.2.7.1.3.3 Area A North and South Catwalks*

In Area A the Kanne systems are used to provide monitoring for diffuse emissions. These systems include integrating electrometers and are also used on the tritium stacks when tritium experiments are being performed in Area A. When tritium experiments are running, the electrometers are connected to the Central Control Room.

#### *3.3.2.7.1.3.4 Area A East*

The Kanne chamber located in Area A East is used to detect air releases from the beam stop area. It provides a local alarm signal to warn personnel of radioactive gas before they enter the area. This system is also used for diffuse emissions reporting.

#### *3.3.2.7.1.3.5 Area C*

This Kanne chamber is used to determine the requirements for personnel access.



#### *3.3.2.7.1.3.6 Ring Equipment Building*

The Kanne chamber inside the Ring Equipment Building (REB) monitors radioactive air inside the Proton Storage Ring (PSR). It is used for monitoring diffuse emissions. The PSR ventilation system is closed during beam delivery. Before entries are made, the ventilation system must be turned on and the air discharged to the stack for 15 min.

#### *3.3.2.7.1.3.7 Tritium Monitors*

Tritium monitors are used on experiments or in areas where tritium releases may occur. The detectors include fixed location tritium monitors (Johnson Triton 955B), portable tritium monitors (Overhoff Portable Tritium Monitor Model 394, or the Johnston Triton Models 110 & 111), and portable Kanne chambers (described above). All instruments, except the portable instrument, are connected by AOT-6 to provide alarms to the central control room (CCR).

#### **3.3.2.7.2 Stack Discharge Air Activation Detectors (FE-2, FE-3)**

Activated air is created when intense radiation passes through the air. Possible spaces with this condition have controlled air exhaust. Exhaust Fan 2 (FE-2) vents the Line-D tunnel, PSR, WNR, and the MLNSC areas. Exhaust Fan 3 (FE-3) vents air from Area A, Area A East, Area B, Area C, and the switchyard. Air is collected from these areas, filtered with HEPA filters, and discharged to the environment. Air that is being discharged is monitored in accordance with 40 CFR 60 and 61 Subpart H. ESH-1 and ESH-17 are responsible for the operation and maintenance of this monitoring system. ESH-1 is involved in the daily activities of running the system and reporting the monthly emissions. ESH-17 is responsible for administering the program and reporting Laboratory effluent discharges to the DOE and EPA. The document "Los Alamos National Laboratory LAMPF Quality Assurance Project Plan for Radioactive Air Emissions Management" (Quality Assurance Project Plan) is the quality assurance document which describes the entire measurement operation and provides the checks to assure that quality of the system is maintained. The "Los Alamos National Laboratory Procedures for use with LAMPF Quality Assurance Project Plan for Radioactive Air Emissions Management" (QA Procedures) is a the collection of procedures from participating organizations and contains the step-by-step procedures for collecting and analyzing all collected data and the detailed procedures for meeting the requirements of the Quality Assurance Program Plan.

The stack monitoring systems consist of the following major components:

- (1) A Kanne chamber with a LANL Model 39A integrating electrometer is used to measure the gross activity of radioactive gas being discharged from the stack. Signals from the FE-3 Kanne chamber are monitored continuously by the computer in the Central Control Room. This provides a check that the system is functioning correctly. The system is checked daily by an ESH-1 technician for proper operations and the results of the daily checks are provided to the ESH-1 staff for review and corrective actions on any deficiencies. This procedure is covered in procedure "Daily Surveys of Air Monitoring Equipment" (TA-53 DP-007). ESH-1 performs a Kanne chamber performance test within 30 days prior to and after each operation cycle of the accelerator. The procedure that details this performance test is "Detailed Procedure for Performance Testing of the Kanne Air Flow-Through Ion Chamber Used on the Monitored Stacks at TA-53" (TA-53 DP-004).
- (2) A high-resolution gamma spectroscopy system, the Canberra Genie PC with a high purity germanium detector, is used to determine the calibration factor of the Kanne chamber and to determine the isotopic composition of the radioactive gas. This instrument is run nearly continuously in the Pulse Height Analysis (PHA) mode. Periodically, a grab sample is captured in the sample volume and is allowed to decay in place. The resultant decay curve from the analyzer running in the Multi-Channel Scaler (MCS) mode is fit to determine the fractions of the positron emitters of the sample. The results of the two measurements and many replicate runs are used to determine the isotopic composition of the radioactive gas and provide a calibration for the ion chamber. This operation is covered in the detailed procedures "Data Collection for Gaseous Emissions Determinations at FE-2 and FE-3" (TA-53 DP-005) and "Data Reduction of the Monitored Stacks at TA-53" (TA-53 DP-006). The Genie system is calibrated twice each year, once within approximately 30 days prior to planned beam operations and once within 30 days after beam operations cease. All calibrations of the system are performed by the TA-53 ESH-1 staff following "Detailed Procedure for Calibrating the High Purity Germanium System Used on the Monitored Stacks at TA-53" (TA-53 DP-003).
- (3) Paper and activated charcoal filters are used to measure the radioactive particulate and vapors being discharged. The filters have radioactive air pulled through them at a rate that maintains an isokinetic flow at the probe tip. This was experimentally verified by ESH-5, using EPA-approved methods for given stack flow rates. The Laboratory's maintenance services contractor measures these stack flow rates at least once per year to verify that the stack flow is within acceptable range for the sampling and for EPA reporting. The procedure is "Exhaust Stack (RAEMP) Air Flow Measurements"

(PM1 40-25-002). Documentation concerning the details of the probe location and sampling rates can be found in the AOT-7 stack documentation file at TA-53.

The filters are changed once per week as prescribed in the procedure “Collecting and Processing Stack Air Particulate Samples” (TA-53 DP-404). This procedure describes the sample preparation, collection, chain of custody (further described in “Chain of Custody for Radiological Samples” [ESH-1-01-04]), and delivery schedules to HPAL for analysis. HPAL then analyzes the samples following “Detailed Procedure for Gamma Spectroscopy of LAMPF Stack Filters and Water Samples” (HPAL DP-04). The results of the analysis are then sent to the ESH-1 staff for further analysis and reporting as described in the “Detailed Procedure for Data Reduction and Reporting of the Monitored Stacks at TA-53” (TA-53 DP-006). The results are then sent to ESH-17 for reporting to the DOE and EPA.

- (4) Silica Gel is used to quantify the tritiated water vapors being discharged out the stack. A 100 cc/min. of gas from the stack is passed over silica gel for one month or until the gel begins to turn white. At the end of the reporting period or when the color begins to turn, the samples are removed and delivered to CST-9 for analysis and the gel is replaced. Details of this process are spelled out in “Detailed Procedure for the Tritium Sample Exchange on Monitored Stacks at TA-53” (TA-53 DP-002). Once the samples are delivered to CST-9 the samples are analyzed in accordance with “ER 210 EM-9 Procedure: Tritium in Environmental Matrices - Distillation Procedure.” The results are then sent back to ESH-1 staff for further analysis and reporting to ESH-17 following established procedures (TA-53 DP-006).
- (5) Air flow monitoring devices used to monitor and record the air flows require periodic calibration. These devices are calibrated by the ESH-9 Standards and Calibration group. There the response of the monitoring devices to NIST standards is measured and the devices are recertified for a pre-determined period. The procedure for calibrating these systems is covered in “Procedure for Calibration of LAMPF Stack Flow Rate and Pressure Monitoring Equipment” (MP-7-OP-9-1.01). The calibration process requires that components be removed from the system. Any time an item is removed or inserted into the plumbing for any of the monitoring systems a leak check must be performed. The procedure for performing these leak checks is “Procedure for Leak Checking Sample Lines at LAMPF Stacks” (MP-7-OP-9-5.01).  
All of the air-moving pumps used to pull samples of the radioactive air from the stacks to the monitoring devices require maintenance, which is performed monthly by support and maintenance operations contractor personnel. This function is administered by ESH-17, the Air Quality Group and the procedure is “JCI Procedure:

Exhaust Stack (RAEMP) Air Monitor System Maintenance, Repair and Installation” (M1 40-25-002 ).

- (6) Systems used for monitoring of the stacks include Run Permit interlocks on the stack fans. One interlock is on is the electrical current monitor attached to the fan motor contacts. The second interlock monitors airflow with a pitot tube array located at the top of the stack. It provides a pressure drop signal to a photo-helic (a pressure-measuring device with an electromechanical limit interlock). The Central Control Room follows a written procedure if a fault occurs.

#### **3.3.2.8 Water Activation Monitoring**

Activated water is produced principally in cooling magnets, targets, and experiments in primary beam areas facilities. Activated water is confined to closed-loop systems with heat exchange to the cooling tower or chilled water systems. Tower water discharge is monitored to ensure it meets effluent standards. Table 3-8 lists the water systems that are sampled for activation products. Most are sampled at the beginning and end of the run cycles, except when IP-REF operates its water system is checked weekly. The samples taken from the water systems are a 100 cc volume used for high resolution gamma spectroscopy and a 10 cc volume for tritium analysis. The results from the analysis are sent to the ESH-1 personnel at TA-53 for review and reporting to the facility.

The south lagoon (radioactive waste water; use to be discontinued in 1996) is sampled by CST-7 and analyzed by CST-9. The results of these reports are sent periodically to ESH-17 for inclusion in the annual LANL Site Environmental Surveillance Report.

#### **3.3.3 Dosimetry**

The LANL dosimetry program is administered by groups ESH-1, ESH-4, and ESH-12. ESH-1 provides the field application of dosimetry through SOP and RWP processes, issues dosimeters in the field, provides radiological data to initiate dosimetry requirements, and serves as the liaison with the other ESH groups. ESH-4 provides external whole-body, extremity, accident dosimetry and *in vivo* bioassay for internal dosimetry. ESH-12 provides oversight and guidance for the dosimetry program, which includes dose assessment, *in vitro* bioassay for internal dosimetry, and administration of the Health Physics Checklist. Additional information regarding Laboratory-wide dosimetry practices is available in “Radiation Dosimetry Monitoring” (LS 107-07).

**Table 3-8. Monitored water systems.**

System	Sector	Level	Function
A02	A	low	DTL drift tubes & quads
A03	A	low	DTL tank walls
J01	J	low	injectors and 750 keV beamlines
B02-G02	B-C	low	SCL magnets
MPF-64 etc		low	Cooling towers
X02	SY-M	high	northside targets, beamstops, & IP-REF
X03	SY-M	med	Line A magnets
X04/6	SY-M	med	SY and A1 cell
X05	M	low	secondary beamline magnets
X07	M	low	Line B- Line C
A4-ESA	M	low	other Area A magnets
Rover	M	low	EPICS spectrometer
W02			Line D South, 1L cell, beamline to Target 4
1L Moderator		high	1L moderator
1L Target-Reflector		high	1L target, reflector, and beamline window
PSR		med	PSR & its beamlines, H <sup>0</sup> & halo beamstops
Target 4		high	Target 4

The Health Physics (HP) Checklist (ES&H Form 3-1A) is a tool used by the radiation protection organization to assess the need for personnel dosimetry on a case-by-case basis. The HP Checklist is used to assess the potential for external and internal exposure, depending on an individual's job assignment and anticipated exposure to radiological hazards. The HP Checklist is completed by the individual, the individual's supervisor, ESH-1, and ESH-12. Based on the data from the Checklist, an individual is assigned to the appropriate dosimetry program until the job assignment or radiological hazards in the area change significantly. Every LANL employee, contractor, and subcontractor must complete a HP Checklist at the start of employment or change of assignment. It is the line manager's responsibility to ensure that HP checklists are completed.

### 3.3.3.1 External Dosimetry

Personnel including visitors at TA-53 are assigned to the external dosimetry program based on the potential for external exposure due to facility operation according to Laboratory and DOE policy (10 CFR 835). External radiation exposure at TA-53 is monitored and evaluated primarily through the use of thermoluminescent dosimeters (TLDs),

TLD finger rings, supplemental pocket ionization chambers (PCs), and supplemental neutron dosimeters. The type of dosimeter for each worker is based on the HP Checklist process, SOPs for routine work, and RWP for non-routine work.

The basic whole-body dosimeter is a four-element TLD system, capable of measuring nonpenetrating and penetrating dose including neutron dose (with the application of neutron correction factors determined for characteristic neutron spectra).

TLD rings are assigned to individuals who routinely perform hands-on work with radioactive materials with a significant potential for extremity exposure as defined previously. Two types of TLD rings are used at TA-53, one type for measuring non-penetrating dose and the other type for measuring penetrating doses, with neutron dose determined using appropriate neutron-to-gamma ratios. The ESH-1 staff at TA-53 select the type of ring to be used, depending on the type of radiation hazard that is involved. The rings are returned at the end of each use to ESH-4 for analysis.

Supplemental electronic dosimeters or PCs are worn by individuals at TA-53 who work in radiologically controlled areas with a reasonable potential for higher than the above levels of external radiation exposure. These dosimeters are used to give the worker “real-time” exposure estimates to help keep exposures ALARA. Electronic dosimeters and PCs are not used for official dose measurements. The need for supplemental dosimetry is determined by ESH-1 on a case-by-case basis, as documented in applicable SOPs and RWPs. Supplemental dosimetry is typically issued for entry into high radiation areas, work that would deliver 100 mrem in a single evolution, work where dose rates are unknown but anticipated to be high, and in other circumstances requiring real-time or high resolution tracking. At TA-53, real-time exposure results are used in conjunction with the TLD results by line managers to keep exposures ALARA and below administrative requirements.

Supplemental neutron dosimeters, PN-3 or other, may also be issued to employees working in the experimental areas. These dosimeters are used in the same way as the TLDs described earlier. Neutron dosimeters provide additional exposure information because they are more sensitive to energetic neutrons typical of accelerator facility spectra.

Dosimetry results are reviewed by ESH-1, TA-53 line managers, and the individual employee. This review allows for trends to be identified, retrospective dose investigations to be initiated, and appropriate control measures to be implemented as detailed in each organization’s ALARA program.

### **3.3.3.2 Internal Dosimetry**

The internal dosimetry program at LANL estimates doses from intakes of radioactive material. Two types of internal dosimetry methods are employed at TA-53 and LANL: *in*

*vitro* and *in vivo* bioassay. The initial type and frequency of bioassay are determined by the HP Checklist process. Modified requirements may be indicated based on changes in job duties or indications of higher potential for exposure such as positive nasal smears, positive air sampling results, and contamination incidents. Personnel permanently assigned to areas where they could accidentally inhale or ingest radionuclides or absorb them through the skin or through cuts are required to participate in the internal dosimetry program.

*In-vitro* bioassay is the analysis of blood or urine, feces, or other body waste to measure possible internal deposition of radionuclides. This technique is used to measure the internal presence of beta emitters, such as tritium, or alpha emitters such as uranium. From the amount of radioactivity detected in the bioassay samples, along with models derived from human and animal experiments, the dose to workers can be estimated. Bioassay kits are distributed by ESH-12, and individual kit recipients are responsible for chain of custody. Cognizant line management is responsible for ensuring program participation, appropriate kit handling, and documentation.

*In vivo* bioassay, also referred to as whole-body counting, involves the detection of internally deposited radionuclides by measuring the x-ray or gamma photon they emit. It is also used for measuring the x-rays emitted by insoluble alpha emitters, such as plutonium oxide, that are deposited in the lungs. The minimum frequency of *in-vivo* bioassay for most radiation workers with a reasonable potential of exposure is once per year. Another type of *in-vivo* bioassay is wound counting, performed by direct measurement of radioactivity in wounds with analytical instruments. Wound counts are performed when a cut or abrasion is suspected to be contaminated with radioactive material.

Analysis of nasal smears is used to indicate potential inhalation of radioactive material by radiation workers. Nasal smears are collected from individuals who

- are involved in any job requiring full-face respirators where, during the course of work, radioactive contamination was detected;
- are in the room or immediate vicinity when a continuous air monitor (CAM) alarm sounds, unless it is immediately determined to be false.
- are present in any area where a suspected spill or release of radioactive materials may have occurred with the potential for air borne radioactivity as indicated by positive contamination surveys or portable air samplers.
- have skin or personnel clothing contaminated with radioactive material; or
- have protective clothing that is found contaminated and it was not anticipated as a result of specially controlled activities (e.g., "hot jobs" where respiratory equipment was used).

Decisions to require follow-up bioassay or to administer medical treatment are based on bioassay results; nasal smear results; the chemical, physical, and isotopic form of the material; surface contamination survey results; air monitoring results; and the duration the individual was exposed to a source. These parameters are all evaluated by ESH-1, ESH-2 (the Occupational Medicine Group), ESH-4, and ESH-12 to determine the probability of significant uptake of material, and to initiate appropriate remediation. This remediation may include participation in diagnostic monitoring programs or more invasive measures such as wound excision or chelation therapy.

Finally, internal dosimetry evaluations are performed on radiation workers at several points in their careers: when new employees are hired at the Laboratory (based on the HP [Health Physics] Checklist), when females notify their supervisors or ESH-2 that they are pregnant, and when employees terminate their employment at the Laboratory. ESH-12 analyzes and interprets internal dosimetry data, and results are reported to ESH-1, cognizant line managers, and the employee.

### **3.3.3.3 ALARA Policy and Program**

Worker radiation exposures are kept As Low As Reasonably Achievable through organizational programs and formal work processes. An ALARA Coordinator is assigned and a formal ALARA program is established in organizations that have the potential for incurring significant exposures. At the group level, a program is established if the group has the potential for a cumulative exposure of 0.5 person-rem per year or more, or if the group is involved in activities that present a potential for contamination exposure. The Laboratory ALARA program and goals are given in the "Occupational ALARA Program" (PED 107-01). and "Radiological Performance Goals Program" (LS 107-05).

ALARA program activities include:

- setting annual ALARA goals and performance measures;
- tracking and trending of doses recorded on monthly TLD reports and tracking and trending of job-specific doses;
- pre-job planning for radiological work;
- job-progress post-job reviews;
- institutional and job-specific training;
- ALARA review of new and modified facility designs;
- application of lessons learned from radiological work.

Doses are kept ALARA through practices such as:

- minimizing radiation exposure time;
- eliminating unnecessary work in radiation fields;



- taking advantage of decay times of activated materials;
- maximizing distance from the radiation source;
- use of special tools and remote handling;
- use of temporary shielding;
- radiation surveys and area monitoring;
- optimizing work efficiency and minimizing dose by job assignments;
- use of personal protective equipment such as respirators and anti-c clothing.

ESH-12, Policy and Program Analysis, has institutional responsibility for the Laboratory ALARA program. ESH-12 reviews facility designs and plans for major radiological work, performs audits of organizational ALARA programs, performs trending and analysis of radiological parameters, and disseminates lessons learned and good practices. ESH-4, Health Physics Measurements, provides dosimetry services.

### **3.3.4 Fire Detectors, Alarms, And Protective Systems**

Fire protection systems at LANSCE have been designed and installed in accordance with the requirements of NFPA standards and the improved risk criteria of AEC/DOE orders. Current design requirements are described in the Laboratory's *Loss Prevention Standards Manual* (Facilities Engineering Design). Fire protection systems consist of automatic sprinklers, detectors, audible and visual alarms, and communications. Alarm signals in a building or set of buildings are transmitted to a concentrator in the immediate area and then to the Los Alamos Central Alarm Station (CAS) and the Los Alamos Fire Department. These signals also provide an indication of the alarm location.

#### **3.3.4.1 Alarm Systems**

Alarm systems are activated by heat and combustion product detectors, manual pull boxes, and automatic sprinkler pressure and flow detector devices. The linac tunnel, beam channels, and MLNSC and WNR target areas do not have sprinklers but do have heat detectors.

Manual fire alarm pull stations which activate visible and audible fire alarms are located adjacent to permanent building exits in accordance with NFPA 101. Pull stations and detector systems are inspected annually.

#### **3.3.4.2 Fire Suppression Systems and Water Supply**

With the exceptions noted above, buildings with possible losses that could exceed the maximum potential fire loss criteria of DOE Order 5480.7A are protected by wet-pipe automatic sprinkler systems that are maintained, inspected, and tested bi-monthly according to

NFPA 13. The fire protection water delivery system, including outside fire hydrants, was designed to meet NFPA 24 requirements. All sprinkler systems are hydraulically designed to function under minimum supply conditions. The required fire hydrant flow meets the standards required by LANL, NFPA, and DOE Order 5480.7A or DOE Order 6430.1A. Portable Halon and CO<sub>2</sub> extinguishers are provided at key locations in accordance with NFPA 10. Building managers are responsible for inspections of portable fire extinguishers, which are inspected on a monthly basis. Sprinkler systems are inspected periodically by the Laboratory's support services contractor.

#### **3.3.4.3 Los Alamos Fire Department Response**

LAFD response from Fire Station One at TA-3 to TA-53 facilities normally takes eight to twelve minutes. The type of LAFD equipment and the number of personnel responding to an alarm depend on information received from the incident location, but as a minimum consist of a rescue vehicle, an engine, its crew, and a battalion chief. Snow, rain, road conditions, or traffic can add to the response time.

#### **3.3.5 Combustible Gas Detectors**

Combustible gas detectors are used throughout the site wherever there may be an accumulation of hydrogen in air exceeding the lower flammable threshold.

The largest quantity of hydrogen in routine use is in the MLNSC hydrogen moderator system. This system, located in the Target 1 Service Cell and Service Area, contains about 8 liters of liquid hydrogen at up to 180 psi (1.24 MPa) pressure; additional bottles of hydrogen gas are stored outside the building (see Section 4.4.4.1).

A combustible gas detection system continuously monitors ambient air for the presence of a hydrogen leak from the MLNSC Liquid Hydrogen Moderator System during periods when the moderator system is filled. One detector is located in the target cell and two detectors are located in the service area, one above the heat exchanger and one above the helium refrigerator. Hydrogen concentration above the set limit will trigger the alarm system and automatically vent the hydrogen gas in the system through a dedicated vent stack. The MLNSC target data collection computer will notify the cryogenic operator on call, who will respond by securing and inspecting the system.

The combustible gas detectors are designed to meet the requirements of "explosion proof" Class I, Groups A, B, C, and D, Division 1, as specified by the National Electrical Code. They operate on the principle of catalytic combustion, which raises the temperature of the detector and, consequently, its electrical resistance in a Wheatstone bridge, to produce an output signal proportional to the combustible gas concentration.

### 3.3.6 Oxygen Deficiency Detectors

Experiments at LANSCE occasionally utilize substantial amounts of cryogenic inert gases such as liquefied nitrogen and helium; conditions that could lead to asphyxiation are possible. The oxygen sensor and warning system monitors the oxygen content of the ambient air and initiates auditory and visual warnings and emergency responses if the oxygen level falls below the OSHA threshold level of 19.5%.

. The systems consist of fuel-cell type sensors, processing electronics, digital display, and alarms with remote sensor stations and a central control station. Two sensors are located at each station and unless both sensors are reporting a low oxygen level, the logic device does not trigger an alarm or other response. These systems are installed in several areas in LANSCE and can be activated as required. Commercially available units, such as the Delta-F, may be used in lieu of these systems.

The most extensive system is in ER-1. Four fuel cell type sensors are permanently installed at high and low points in ER-1 and are connected to the ER-1 Evacuation Alarm system, with trip points set at 19.5% oxygen. These sensors require periodic replacement and frequent calibration adjustments to avoid false alarms due to cell depletion. Hand-held oxygen sensors are also provided to experiment personnel and operators, to be carried when persons enter ER-1 if an alarm has sounded.

The ER-1 Evacuation Alarms are very loud, battery powered continuously chiming bells on two opposite sides of the room. They ring under any of the following conditions:

- low oxygen sensor trip;
- inadequate ER-1 room exhaust duct flow;
- inadequate polarizer cave exhaust duct flow;
- loss of room electric power;
- switch actuation in the Central Control Room; or
- switch actuation at any ER-1 exit doors or at the ER-1 Evacuation Alarm panel.

Procedures for alarm response and several circumstances for manually initiating the alarm are published in SOPs and briefed to new personnel. The alarm will continue to ring until reset at the indicator panel; it cannot be reset if the initiating signal is still in effect.

Portable oxygen deficiency detectors are used in other confined space areas, as determined by ESH-5